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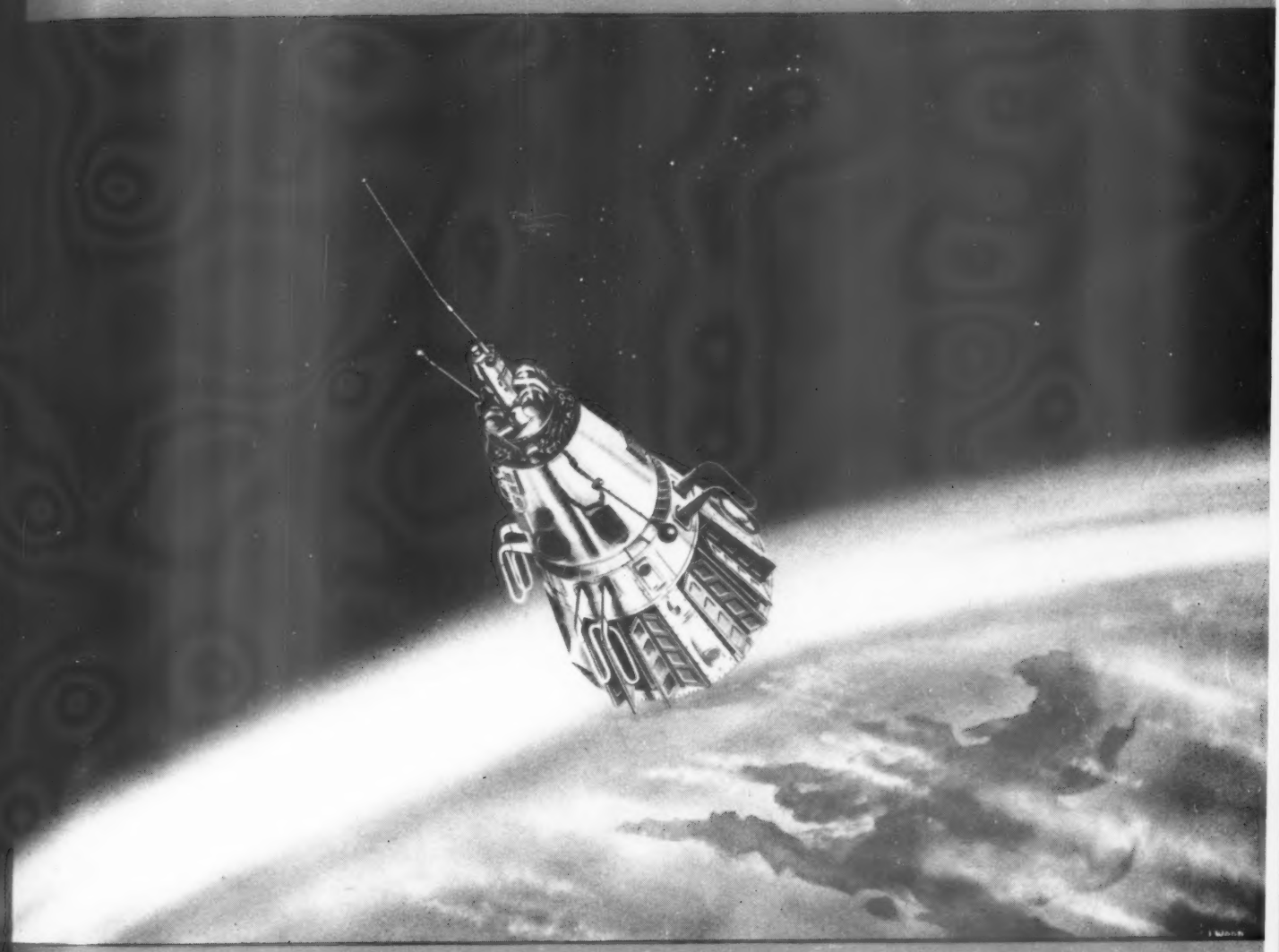

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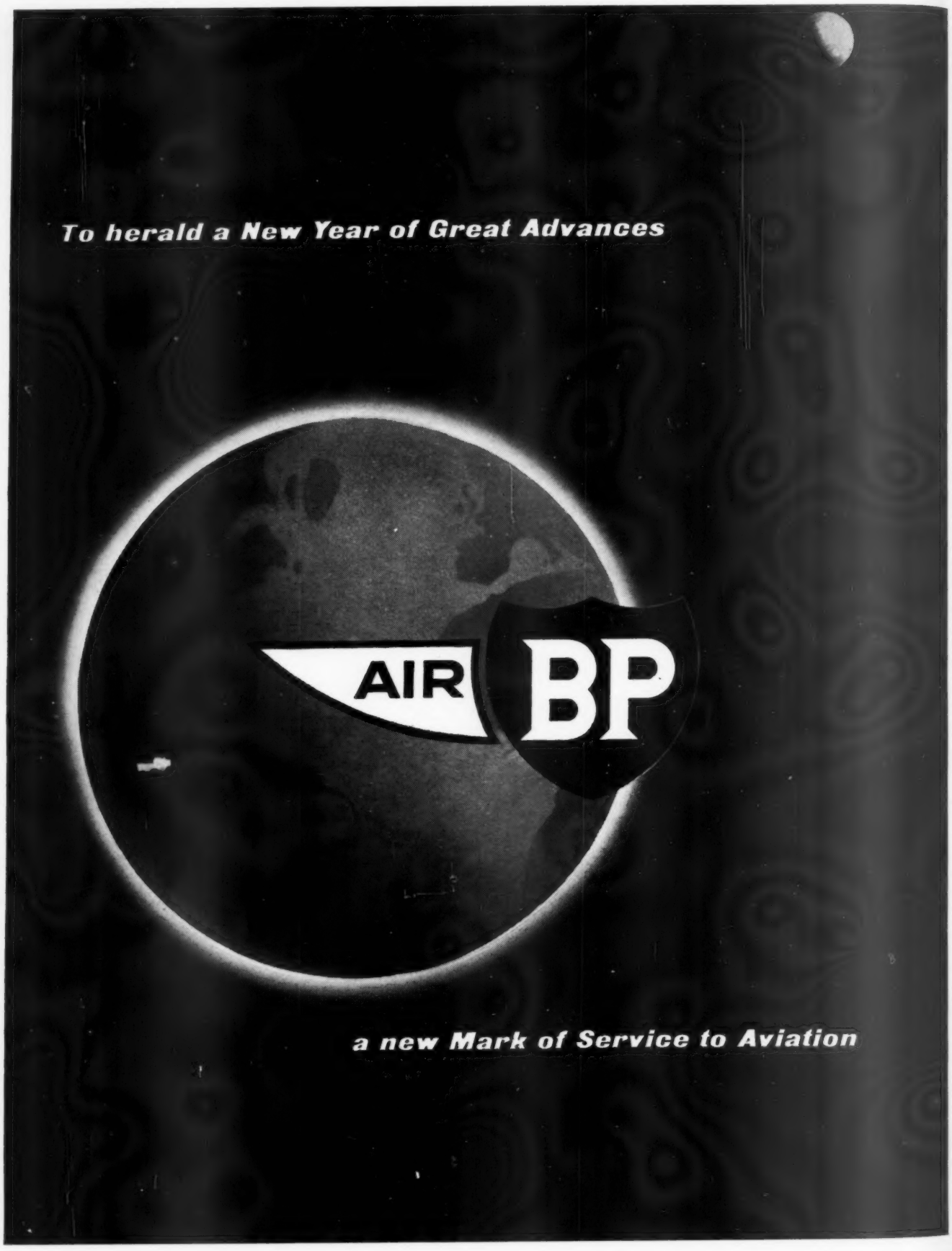
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SPACEFLIGHT

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Editorial

When Volume 1, No. 1, of *Spaceflight* appeared, in the autumn of 1956, astronautics was still a science of the future. So much has happened of late that it is sometimes hard to realize that it is only some fifteen months ago that the Russian Sputnik gave practical proof that the Space Age was almost upon us; now, as the first issue of Volume 2 of our periodical goes to press, we have seen America's Pioneer reach out to one-third the distance of the Moon.

In this age of progress it is really amazing to find that there are still a few otherwise rational people who regard the space-travel concept as either impossible or else futile. Since the launching of Pioneer, these curious folk have become vocal once more, and have even taken scientists to task for their "arrogance" in saying that space-travel *will* be achieved, instead of *may* be achieved.

We need waste little time upon comments of this intellectual level. Much the same things were being said about heavier-than-air flying machines less than seventy years ago. Meanwhile, the satellites and probe vehicles exist, in fact as well as in imagination, which is sufficient answer to the "critics".

My thanks are due particularly to our two American contributors, Frank Pollard and Prof. W. H. Haas, for taking so much trouble to prepare their papers quickly for the present issue.

PATRICK MOORE.

COVER

Sputnik III in orbit. This painting, by John Wood, shows the third Russian satellite as it must have appeared during its journeys round the Earth.

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I.A.F. CONGRESS, 1959

The 1959 I.A.F. Congress will be held in London during the week commencing August 31. Further details will be announced later.

Rocket on the Moon

By T. W. RACKHAM

When a rocket is sent to the Moon how will we know that it has really arrived? And what marks will it make?

With Sputniks 1 and 2 already circling the Earth every 100 minutes or so, I was asked to undertake a "Moon-watch" for the *Time-Life Magazine* last November. At that time it was thought that the Russians might try to round off their very successful enterprises, and celebrate the fortieth anniversary of the Soviet revolution, by attempting to hit the Moon with a rocket. My task was to try to maintain a constant watch—as far as conditions would allow—and to report and, if possible, photograph any unusual happenings which might occur. It is hardly necessary to say that, although long vigils were made at the telescope, nothing unusual was seen. Had there been anything to report the banner headlines of the press would have proclaimed it to the world long before now.

Nevertheless the science of rocketry is advancing at such a rate that the impossible today becomes the commonplace tomorrow; and who would be so bold as to say that the lunar surface will not receive a terrestrial visitor within the next few months? At the moment the two contestants in this field are the U.S.A. and the U.S.S.R. and there must be a tireless and highly secret race going on between them to perfect a space vehicle which can be directed to the Moon. If either side is to succeed, it means that the already achieved velocities of 18,000 miles per hour will have to be increased to 25,000 miles per hour to allow a rocket to break through the gravitational bonds which hold it to the Earth. But this is only one of the formidable tasks which confront the scientists and engineers concerned, and, while they may yet regard it as the most important, there is another problem which must also be solved. Having successfully launched a rocket, they must be able to state with complete assurance that the rocket actually arrived, and it must be possible to define its exact position on the lunar surface.

The ever-increasing rate of scientific progress makes the prophet's mantle an uncomfortable garment nowadays; but, at the time of writing, it seems unlikely that the final payload of such a rocket can be very large—perhaps no more than a few pounds in weight. How then can its arrival on the Moon be detected from the Earth? This problem dominated my thoughts during the long hours of "Moon-watching", and it voiced itself in this way—"What ought I to be looking for?" "What should I see if a rocket did hit the lunar surface?" and so on. These are questions worthy of our closest attention.

T. W. RACKHAM

To the unaided eye the full Moon looks pale and ethereal: the telescope reveals it as 7·5 million square miles of waterless desert, and there is an equal area in the averted hemisphere of which only the edges, or the libratory regions, can be observed from the Earth. Not all of the surface facing us can be studied, for each circular formation and mountain mass, other than those situated in the central regions, possesses its own averted slopes which constitute "blind spots" for the observer at the telescope. And because the Moon is smaller than the Earth it must not be assumed that the mountains are scaled down accordingly; some of them are higher than any on the Earth's surface. This means that a rocket despatched from the Earth could quite easily hit the observable lunar surface, and yet be lost to view behind a crater wall or a mountain range. This is a hazard which must be risked, since there is a far greater chance that the rocket will miss the Moon entirely and will career away into the vastness of space.

So much for the first difficulty. The second is even more serious and fundamental, for here we are concerned with the optical ability of a telescope to define small

objects on the lunar surface nearly a quarter of a million miles away. The largest telescope in the world is the 200-inch reflector on Palomar Mountain, in California. This telescope, on account of its tremendous aperture, is able to resolve smaller detail on the Moon than any other instrument in existence. For example, an observer using this telescope could just see a craterlet if it were 80 yards across,* or a linear formation, such as a rill or a cleft, if it were no less than 5 yards wide—this always assumes perfect optics and excellent seeing conditions. Amateur telescopes of around 12 inches aperture do not show craterlets less than three-quarters of a mile across, and a cleft must be about 70 yards wide if it is to be resolved. These figures dash all hopes of observing a rocket standing on the lunar surface; indeed there seems to be no chance of man ever being able, or for that matter, ever wanting to erect lunar edifices which can be seen in the smaller telescopes.

Celestial objects which lie below the resolving power of all telescopes, but which are clearly visible to the human eye, are the stars; and it has been seriously suggested that one method of witnessing the arrival of a rocket upon the lunar surface would be to pack its nose with flash powder. Upon impact this would ignite to produce a bright if transitory star which could be seen from the Earth. Such an event would provide an interesting exercise for large numbers of widely spaced amateur observers who would be able to time the arrival and determine the exact position of the "hit". The apparent magnitude of the flash could be estimated, and this might yield some clue as to the nature of the surface, while ciné film exposed in the focal plane of an astronomical telescope would provide an enduring record of the event. Widely spaced observers would be used as an insurance against cloud conditions, for it is hardly likely that all observers would be favoured by clear skies.

The most serious disadvantage connected with the flash powder idea is the extreme brevity of the apparition, which, in the unlikely event of all observers failing to witness it, would leave no observable mark on the lunar surface. If this happened, rocket engineers and scientists would never know if the rocket had arrived or not. True, a good deal has been said concerning radio methods of rocket navigation; but there are many gaps in our knowledge, and no one can say for sure whether a radio transmitter could send out signals from the Moon which could be received on Earth. And this assumes that the problem of landing it gently upon the lunar surface has also been solved. In any case, even if all this were achieved and transmitted signals were received well after the estimated time of arrival, there would still remain the problem of finding the rocket's position—for as yet, there is no way of pinpointing objects situated at that distance.

At the present time it would seem that visual aids offer more advantages when applied to the problem of defining the position of a rocket on the Moon, and, bearing in mind the limited payloads that can be sent, it would seem extremely wasteful not to tap the unlimited source of solar energy which is available on the lunar surface in the form of light. One method of doing this would be to jettison numbers of thin flat sheets of highly polished aluminium over a small area of the lunar surface in such a way as to reflect the Sun's light back to Earth, where from time to time observers would see starlike flashes; the flashes being due to the ever varying conditions of illumination on the Moon and the Sun-Moon-Earth angle. These long distance heliostats would betray the rocket's position. Some approximate idea of the brightness to be expected from such flashes can be obtained from existing figures.* To start with, the Sun is about 600,000 times brighter than the full Moon; this means that if it were possible to cover an area of the Moon with a reflecting surface which would give a direct reflection of the Sun, we should expect the same brightness ratio to hold good between the area of reflected light and an adjacent and equal area of average lunar surface. If we carry this a stage further we can deduce that the light reflected from one square mile of average lunar surface is about equal to that received from a star of the 4th magnitude. Ignoring losses due to imperfect reflecting surfaces, etc., this is roughly the same amount as would be reflected from 5 square yards of mirror. This area, if made circular, would have a diameter of some $2\frac{1}{2}$ yards. Even 1 square yard of mirror would be seen as a star of the 6th magnitude, and such stars can be seen without optical aid against a darkened sky: there is every reason to suppose that such an object could be seen against the lunar surface through a medium-sized telescope. If we had any choice in the matter we should prefer to direct these objects to the darker postions of the lunar surface—the maria, where the brightness ratio would be far in excess of 10^6.

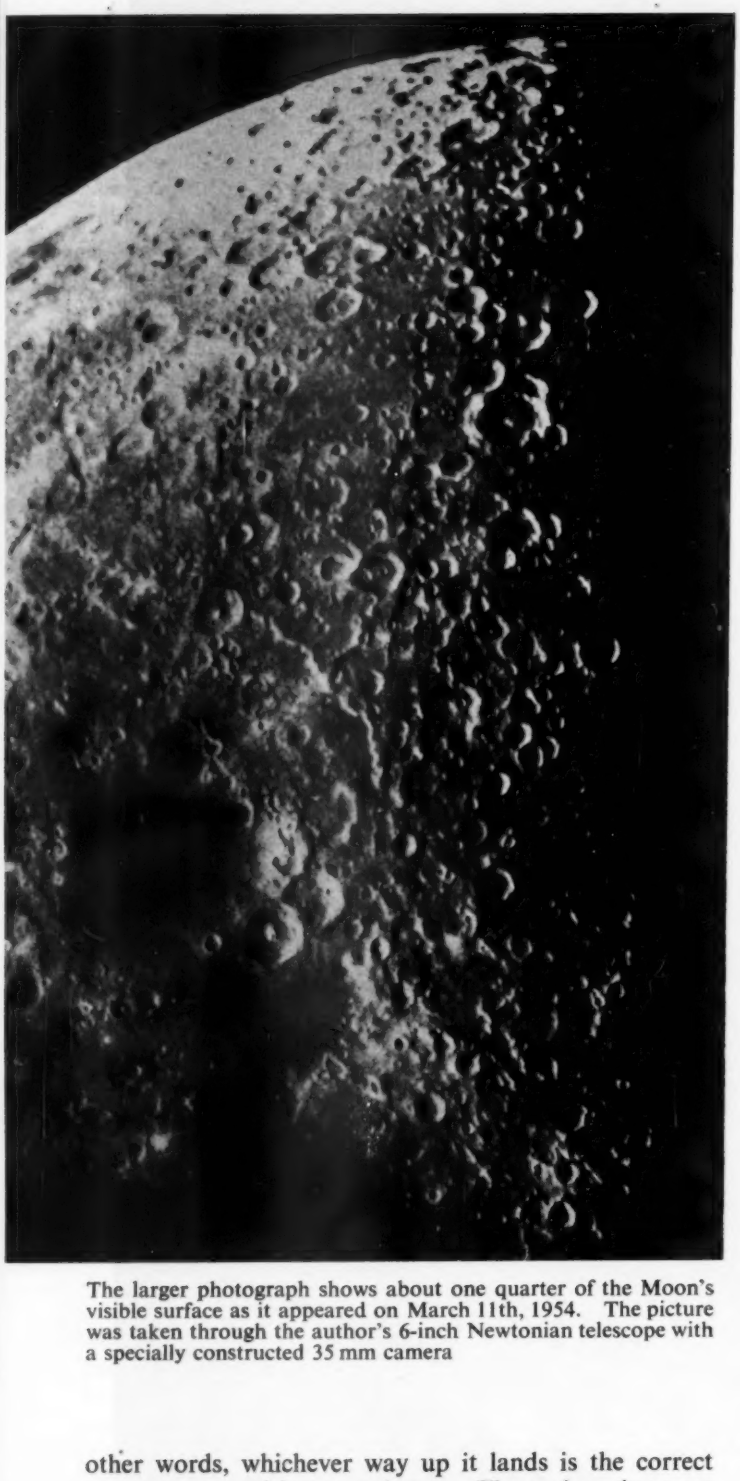
All sensible people shudder at the thought of the H-bomb, and it would be an act of the greatest stupidity to launch such an object at the Moon. Nevertheless we are told that the flash of the H-bomb is brighter than the light of the Sun; and, since the explosion would be very much greater in extent than our lunar mirrors, it could certainly be seen with the naked eye from the Earth and would form a dazzling spectacle for an observer with a telescope.

What other visual methods are there? The dusting of the lunar surface with some highly-coloured or fluorescent pigment has its champions, and there is no doubt that this idea has certain advantages. For example, if the Moon's surface itself consists of dust, as is widely believed, it seems unlikely that a charge of powder exploded above it would be heavy enough to sink in. Heavier objects like our mirrors might well disappear if the dust were thick enough. Secondly, there is no need to "arrange" the dusty pigment; in

* See *The Moon* (Wilkins and Moore), Appendix I.

* See Norton's *Star Atlas*.

The Mare Serenitatis area of the Moon. The white circle encloses an area of about 2,000 square miles, 50 miles in diameter; on this scale the whole lunar disk is 72 cm in diameter. Photograph by T. W. Rackham, 1954, April 10, 6-in. reflector. The Alpine Valley is well shown



The larger photograph shows about one quarter of the Moon's visible surface as it appeared on March 11th, 1954. The picture was taken through the author's 6-inch Newtonian telescope with a specially constructed 35 mm camera

other words, whichever way up it lands is the correct way; not so with our mirrors. There does however seem to be one serious drawback to the dusting method, and this is connected with the use of small telescopes. A small coloured splash about 100 yards across might well be seen with the 200-inch telescope under ideal conditions, but for a 12-inch telescope it would be necessary to colour nearly one square mile of lunar surface. The amount of colouring, moreover, is completely dependent on the weight of material that can be carried to the Moon.

Instead of the few pounds of payload which represents the present limit, suppose that we were able to take one ton of coloured dust and spread it evenly over one square mile of lunar surface. We would find that each square yard was receiving something like 1/100th oz. of material, and the whole area would be so small and the colouring so weak in our telescopes that it is extremely doubtful whether anyone would detect it.

Perhaps the answer to the problem of marking the Moon is already solved; perhaps there will be no need to mark the surface at all, but sooner or later a rocket will arrive and a method of detecting its position will have been discovered.

The close-up, taken from the same picture, shows the great formation Maurolycus and the arrow points to a black dot on its western slopes which represents one square mile of lunar surface. We can see this dot easily because it *is* black; it is not difficult to imagine the problems facing an observer who attempts to find an equal area of very slight colouring after the rocket has 'dusted' the Moon

Pioneer: An Achievement

By FRANK POLLARD

America's record-breaking Lunar Probe which failed to reach the Moon by only the narrowest of margins.

At 3:42·05 a.m. E.S.T. on a warm Florida morning, the four-stage lunar probe "Pioneer" rose from its launching pad at Cape Canaveral in a heartbreaking attempt by the United States Air Force to place the first space vehicle in the vicinity of the Moon. The objectives were clear—to achieve proper vehicle performance, to reach escape velocity from the Earth's gravitational field, to obtain data in space at distances of 250,000 miles from the Earth and to achieve sufficient control of trajectory to insure placing the instrumented payload in the vicinity of the Moon.

On October 11 (launching date) the Moon was some 223,800 miles from the Earth. The flight plan called for a 62-hour rocket flight with intercept taking place when the Moon was within 225,500 miles from the Earth.

The rocket was an 88·1 ft. Abel-1 vehicle consisting of a standard U.S.A.F. Thor weighing 100,000 lb. (150,000 lb. thrust); a second-stage Aerojet-General 1040 liquid propellant engine weighing over 4,000 lb. (7,500 lb. thrust); a third-stage Allegheney Ballistic Laboratories' solid propellant ABL-248 engine weighing 400 lb. (2,500 lb. thrust); and a fourth-stage Space Technology Laboratories' instrument package and a Thiokol solid propellant terminal rocket weighing approximately 83·8 lb. (3,000 lb. thrust).

The 39·6 lb. instrument package was designed to collect and relay information on the magnetic fields of both the Earth and Moon; micrometeorite impingement data; radiation density for the duration of the flight; interal temperature of the package itself and a crude electronic picture of the surface of the Moon. The instrumentation consisted of a magnetometer to measure the gravitational fields of Earth and Moon, an ion chamber to measure radiation density (the chamber had a capability of measuring radiation density of over 1,000 roentgens per hour), temperature gauges to determine internal temperatures and the effect of temperature fluctuations on the instrumentation, an infra-red television scanning camera and instrumentation to measure micrometeorite impacts. The most important item of equipment was the Doppler Command Receiver, designed to fire the terminal rocket on a signal transmitted from anyone of a number of control stations on Earth. The Toroidal-shaped satellite was enclosed in a honey-combed fibreglass shell which slipped over the Thiokol terminal rocket. The instrument package was 29 in. in diameter and 18-in. in depth. Eight vernier rockets were attached around the base of the terminal stage in order to correct velocity as needed. A special paint pattern applied to the outer shell aided in controlling internal temperature. An interesting side note was the sterilization of the satellite and its components to prevent contamination of the Moon's surface in the event "Pioneer" actually hit or impacted on the surface. From the top of the satellite, double antennæ $\frac{5}{8}$-in. in diameter and 16-in. long extended into space and from them was beamed data to the five main tracking station located on the Earth.

The launching was carefully programmed. "Pioneer" was launched vertically and the first-stage guidance system was to roll the rocket to a 71° azmuth trajectory a few seconds after initial firing. The first-stage Thor burned until cut off at about 150 sec. and some 50 miles of altitude where the expended fuel tanks separated. The first stage actually burned 3 sec. too long and resulted in an error in the programming. A malfunction in the autopilot system caused a 3·5° over-correction and, over

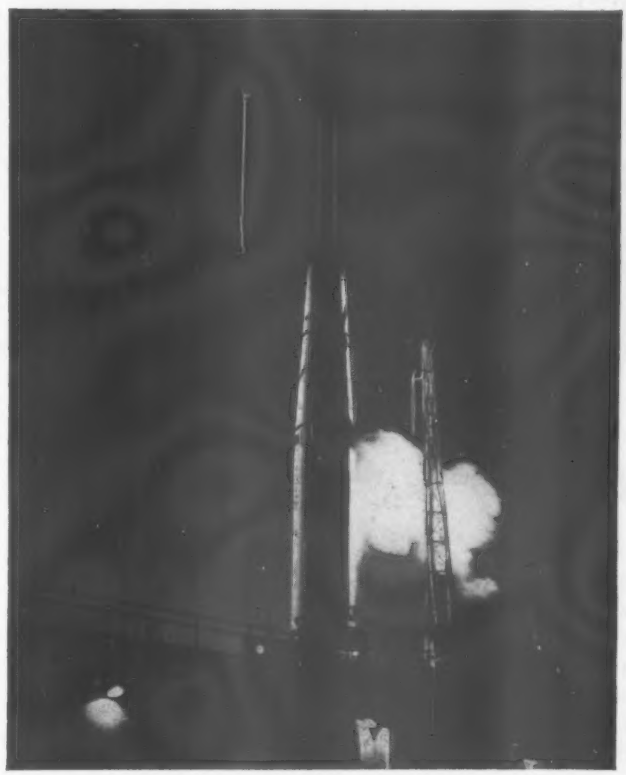
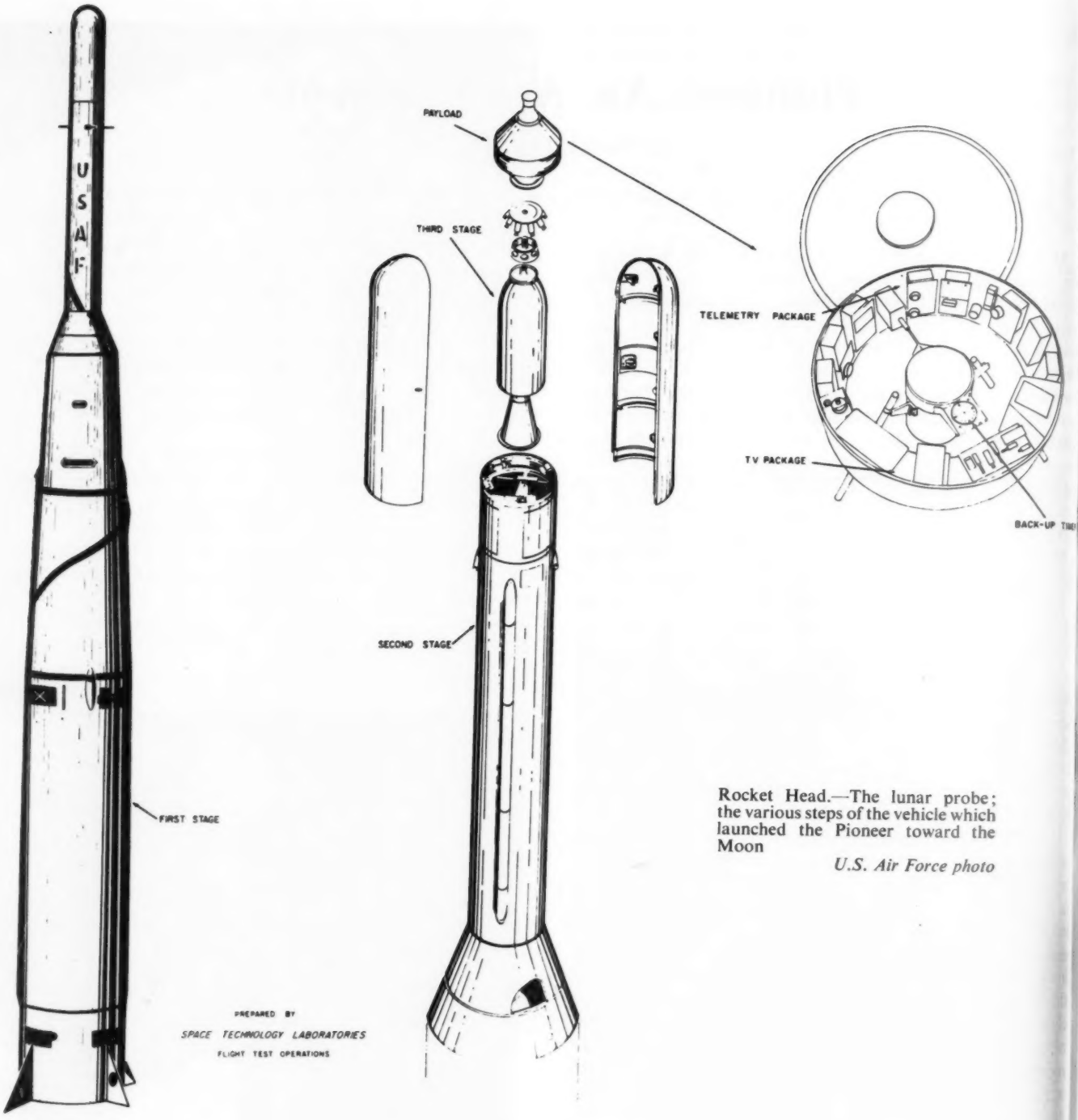


FIG. 1. The Pioneer; pre-launch of lunar probe
Photo by Rogers. U.S. Air Force photo



Rocket Head.—The lunar probe; the various steps of the vehicle which launched the Pioneer toward the Moon

U.S. Air Force photo

the distance of 250,000 miles, placed the rocket quite a way off course. The second stage ignited and burned for approximately 2 min. Explosive bolts then separated a fibreglass fairing over the third and fourth stage and eight stabilization rockets spun the vehicle to about 120 r.p.m. At second-stage separation, ignition of the third stage took place. Shortly following (approximately 8 sec.) the ABL third-stage engine burned out and spring devices separated the third stage.

The fourth stage, containing instrument package, Thiokol rocket and vernier rockets, was now free. In order to increase the velocity (the vehicle was travelling at about 34,500 f.p. 8 min. after launch) all eight vernier rockets were ignited from the control centre. This firing added about 54 m.p.h. to the vehicle. Not enough to reach the velocity of 25,500 m.p.h. necessary to gain the orbit of the Moon. Actually, the rocket attained a speed some 580 m.p.h. short of what was

needed to "do the job". It was calculated that the rocket did achieve an apogee of about 79,000 miles before it started its plunge back into the Earth's atmosphere. Several attempts were made to fire the terminal rocket to gain additional velocity and place the satellite in orbit. Unfortunately, the batteries supplying power could not produce the current necessary to fire. The internal temperature of the satellite was dependent on outer shell paint and Sun orientation. Due to the trajectory error, internal temperature dropped to the point where the batteries would not function. The preflight plan called for the firing of the terminal rocket when the satellite had reached the vicinity of the Moon. This firing was calculated to take place at an angle to its trajectory and increase the velocity of the satellite relative to the Moon. The eight vernier rockets could then have been fired as necessary to correct direction and speed.

At the instant the vehicle lifted from the launch pad, ground tracking stations located at Manchester, England; Singapore, Malaya; Hawaii; Cape Canaveral, Florida; and Millstone, New Hampshire, started receiving telemetry data from the vehicle. Nine Naval Research Laboratory minitrack stations also assisted in tracking. They are located at Ancon, Peru; Antigua, Leeward Islands; Antogagasta, Chile; Cotopaxi, Ecuador; Grand Turk, Bahamas; Johannesburg, South Africa; San Antonio, Cuba; Havana, Cuba; Woomera, Australia; and Santiago, Chile.

The data reduction centre of the Space Technology Laboratories in Los Angeles, California, was the hub of the data and tracking system. As position and data signals were received they were relayed by teletype to the Centre for compilation and analysis. The station at Manchester, England, used the huge radio telescope at Jodrell Bank which recently tracked the Vanguard satellite at distances up to 2,500 miles. This site and the Cape Canaveral and Millstone Mountain, New Hampshire site were able to obtain angular data (bearings). At 11:46 E.S.T., October 12, the Hawaiian station reported that "Pioneer" had plunged into the atmosphere and was destroyed.

The mass of data that flowed in is now being analyzed. The reported radiation band around the Earth was confirmed and figures as to intensity gathered. The radiation count indicated a rate of four roentgens per hr. at about 5,000 miles, three roentgens per hr. at about 10,000 miles and about two roentgens per hr. at 18,000 miles. The fibreglass insulation in the satellite controlled temperature to a great degree and very little dust in space or micrometeorites were encountered. The surface scanning camera did not operate since it was connected to the firming circuit of the terminal stage. Before its plunge into the atmosphere the rocket at apogee floated in a very low gravitational field for a reported 2 hours. This area in space was estimated to be subject to about four-hundredths of the Earth's gravity.

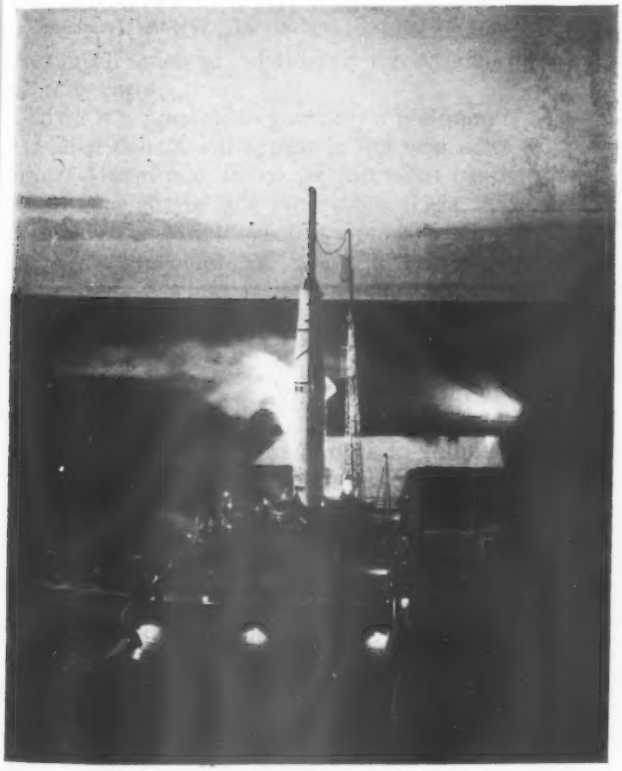


FIG. 2. The Pioneer just before launching
Photo by Rogers. U.S. Air Force photo

FIG. 3. Launch of the Pioneer lunar probe; the rocket is seen leaving upon the journey which took it 79,000 miles out into space
Photo by Rogers. U.S. Air Force photo

The "attempt" was considered an unparalleled achievement in man's race into space. The goal has proved attainable and the United States is planning several more attempts in the near future under the supervision of the new National Aeronautics and Space Administration (N.A.S.A.).

FIG. 4. This photograph shows section of moonprobe terminal assembly as it is fitted to the rocket-propellent third stage

FIG. 5. Scene at the proving ground during the time when the Pioneer lunar probe was in space

Photo by Charles A. Federer, Jr. Reproduced by courtesy of "Sky and Telescope"

Lunar Rocket Observation: I.L.S. Programme

The I.L.S. (International Lunar Society) is organizing a rocket observation programme essentially similar to that described by Prof. Haas in his article; indeed, the two organizations are working together and in the closest collaboration. The I.L.S. researchers, over 50 in all, have "divided up" the Moon so that each observer is particularly concerned with one special section. To take a few examples at random: F. H. Thornton (18 in. reflector) is concerned with Section XIX, R. Barker (12 in. reflector) with XVI, K. W. Abineri (8 in. reflector) with XXII. These section numbers refer to the lunar map drawn by H. P. Wilkins; the numbers are the same as those used in the earlier classic map of W. Goodacre.

The I.L.S. programme organizer in Britain is J. D. Bestwick, who himself covers Section XVIII of the lunar map with his 12 in. reflector. By the time that the first successful landing of an unmanned vehicle is made, it is hoped that the programme will be in full working order.

Of course, nobody yet knows what the circumstances will be. However, there is at least a reasonable chance that work of this sort will produce immediate results of lasting value; and it is satisfactory to find that lunar observers, both professional and amateur, are ready for any eventuality.

Observers who have adequate telescopes and who are interested in playing a serious part in this programme should contact J. D. Bestwick at Iddesleigh, Hartington Street, Leek, Staffordshire.

The Alphonsus Outbreak

By PATRICK MOORE

According to many textbooks, the Moon is a world where all activity ended millions of years ago, so that nothing ever happens there now. True, there have been many reports of temporary obscurations within certain craters, such as Plato, and there is also the case of Linné, which was recorded as a well-defined crater before 1843, but which has certainly not existed in such a form since 1866. However, definite evidence has never been obtained until now, and photographic confirmation has been entirely lacking.

The announcement that a volcanic outbreak inside the crater Alphonsus had been witnessed, and confirmed spectrographically, by the Russian astronomer N. Kozirev was therefore at first received with some scepticism. This scepticism did not, of course, reflect in any way upon Kozirev himself, who is a most distinguished astronomer with an international reputation; it was simply thought that there might have been an error in the interpretation or translation of his report. Since then, more information has come to hand. Much of it was summed up by Professor Zdenek Kopal, of Manchester University, in an account published in late November[1]; I have also had a personal letter from Dr. Kozirev, to whose kindness and courtesy I am much indebted. Evidently the original report was perfectly correct.

So far it is possible to give only a preliminary account, and fuller details will appear in the next issue of *Spaceflight*. Meanwhile, let us see just what has happened.

On the night of 3–4 November, 1958, Kozirev was examining the Moon spectrographically with the aid of the 50-in. reflector of the Crimean Astrophysical Observatory. While guiding a plate, he was struck by a most unusual appearance inside Alphonsus, a prominent crater over 80 miles in diameter near the centre of the Moon's disk, flanked to the north by Ptolemæus and to the south by Arzachel. The central peak seemed to be covered with a reddish "cloud", which was in slow but perceptible motion. It lasted for only a short period (not more than half an hour), but when the spectrograms were developed they showed unmistakable evidence of gaseous emission, and lines due to carbon (C_2 and C_3). For a time, indeed, the spectrum of the central peak of Alphonsus was not unlike that of a comet's head—a description due to Professor A. A. Mikhailov, Director of the Observatory of Pulkovo and Chairman of the Astronomical Council of the U.S.S.R. Academy of Sciences. The inference was that there had been a considerable rise in temperature, and the whole phenomenon bore a marked resemblance to what we would normally call a volcanic eruption. Kopal points out that in this case, we must accept the existence of at least isolated heat pockets under the lunar surface.

In a short time everything was normal once more, but it was clearly important to see whether any change in the area had resulted. Later in November, Dr. H. P. Wilkins at Bexleyheath, England, studied Alphonsus with his 15½-in. reflector, and reported that a smallish patch, rather reddish in hue, had appeared on the southern slope of the central peak. A similar report was made by G. A. Hole at the meeting of the British Astronomical Association in London on 26 November. Hole was using a 24-in. reflector, and at that time had no knowledge of Wilkins' observation.

Subsequent reports have been conflicting. Altogether seven observers had reported the patch up to mid-December; Wilkins saw it again on 19 December. (Using my 12½-in. reflector I have so far been unable to do so, but observing conditions at my observatory have been very poor.) In America, G. P. Kuiper, using the 82-in. reflector at McDonald Observatory, failed to see the patch; the Greek astronomer Focas, working at the Pic du Midi, was equally unsuccessful. Yet we must remember that with lunar observation, everything depends upon the angle of illumination; so far as the patch is concerned, it may well have been "right" for Wilkins and Hole, "wrong" at the time when Kuiper and Focas made their searches. There is naturally no suggestion that the patch is a high-temperature area. Material ejected at the time of the outbreak is the obvious answer; and as there seems no doubt that activity did take place on the night of 3–4 November, traces of its effects are only to be expected.

It is worth noting that in recent months Dr. Dinsmore Alter has mentioned[2] possible temporary obscurations near this area, and there are also several older reports of similar appearances.

One problem which may be re-discussed is that of the origin of lunar craters. At present there are two main theories. One of these attributes the craters to meteoric impacts; a full and most valuable discussion has been published by R. B. Baldwin[3], and in general this hypothesis has been the most favoured of late. The alternative is that the craters were produced by igneous action, as maintained by Spurr[4] and others, including the present writer[5]. It is tempting to say that the Alphonsus outbreak supports the igneous rather than the impact school of thought, and that it is unfavourable to the "dust" hypothesis put forward in 1955 by Gold.[6] However, it is much too early to come to any definite conclusions; any attempt to do so would be premature, to say the least of it.

Astronautically, the main point of interest is that the Moon now seems to be less inert than many astronomers

[*Continued on page 21.*

Some Suggested Observations of Moon Rockets

By WALTER H. HAAS

In this article Professor Haas, one of the organizers of the Moonwatch project, outlines the programme of work being prepared in readiness for successful lunar propelled vehicles.

On October 11, 1958 at 8 hr. 42 min. Universal Time, the United States Air Force launched from Cape Canaveral in Florida a lunar probe called Pioneer. Intended to orbit the Moon and to photograph the invisible hemisphere, Pioneer lacked sufficient velocity and fell back to Earth after travelling outward to a distance of about 79,000 miles from the Earth. Nevertheless, the attempt will be repeated soon; and presumably in a short time lunar missiles will be gathering data in orbits around the Moon or impacting on its surface. While all sorts of special instrumentation will certainly be used to track such missiles, it may also be most appropriate to inquire about what interesting or useful observations can be made by the growing and enthusiastic bands of amateur scientists. In this article I shall limit attention to optical observations with telescopes ordinarily available to amateurs, say 2 to 6-in. refractors and 4 to 16-in. reflectors.

One may first ask whether the lunar missile itself can be observed visually as a slowly moving star-like object. This observation will certainly be difficult, for the Moon missile will look exactly like the countless dim telescopic stars. Only its motion with respect to these stars will reveal its nature to the telescopist; and if the missile is stationary with respect to the Moon at the Moon's distance from the Earth, the angular velocity with respect to the background stars will be only half a degree of arc per hour, or 0·5 per sec. of time. With the limited field of view possessed by telescopes of apertures sufficient to reveal the lunar missile, it is clear that a set of predicted positions will be essential to successful telescopic sightings; and these can hardly be available until electronic positional data on the missile are actually being reduced at the appointed computing centre, telephone communication thus being almost essential. It may be more hopeful to photograph the missile than to see it, but fairly professional equipment is required.

Nevertheless, we should not underestimate the initiative and resourcefulness of some of our colleagues. Assisted by radio data predictions of position, Mr. Lyle T. Johnson observed the Vanguard 6-in. sphere on April 15, 1958, with a 10-in. reflecting telescope of his own design when the sphere's slant range was almost 2,400 miles and when its estimated stellar magnitude was thirteen or fourteen.[1] The angular velocity of the satellite was observed to be about 0·08 per sec. On July 16, 1958, Mr. Johnson made a second observation of the Vanguard 6-in. sphere when it was almost 2,500 miles away and near apogee.[2] On this occasion he employed a 16-in. reflecting telescope and again used predictions for the Minitrack Station at Blossom Point, Maryland, U.S.A., where he lives. If such optical observations are possible upon lunar rockets, it would appear that they might be valuable supplements to radio positional data.

The observational difficulties indicated above are multiplied for a missile which has become a satellite of the Moon. The most thorough search yet made for possible natural lunar satellites was one carried out by Mr. Clyde Tombaugh and his co-workers at the Lowell Observatory during the total lunar eclipse on November 18, 1956.[3] Their procedure was to take photographs while the Moon was dimmed in eclipse, driving the telescope at the lunar rate so that star images became trails. Mr. Tombaugh has computed that a German V-2 rocket at the distance of the Moon, seen broadside and painted white, would be of stellar magnitude fifteen,[4] thus near the limit of visibility in a 10-in. telescope. The early Moon rockets will very probably be much smaller than the V-2, they need not be painted white, and they certainly will usually not be broadside to our view. Since they cannot be more than about 9° distant from the Moon,[3] they will not be seen against a dark sky (except during a total lunar eclipse); and between First Quarter and Last Quarter the Moon's light will interfere considerably with their visibility. We can hardly hope to observe them.

There may be a literally bright exception to this pessimistic conclusion. If the Pioneer of October 11 had achieved its intended trajectory, it was planned to use retro-rockets at the proper moment to send it into an orbit around the Moon. The rocket-flame thus generated would surely be some stellar magnitudes brighter than the rocket itself and might be visible in at least the larger astronomical telescopes. Again, observed positional data would have some value; right ascension and declination of the flame would need to be determined, along with the corresponding times. The flame would be star-like, for at the distance of the Moon a second of arc is about 6,000 ft. Of course, the observer would need advance knowledge of when and where to watch for this phenomenon.

Let us now inquire what we may hope to observe when a lunar missile strikes the lunar surface. It has

been computed by Dr. Lincoln La Paz, on both empirical and theoretical grounds, that a meteorite with a mass of 10 lb. impinging directly upon the surface of the Moon with its cosmic velocity unreduced should create an impact-flash of about the sixth stellar magnitude and hence visible to the unaided eye from the Earth.[5] The brightness of the flash would be proportional to the kinetic energy of the impacting body, thus varying directly as the product of its mass and the square of its velocity. The early moon rockets may have masses up to a few hundred lb., but their selenocentric velocities at impact will be very small compared to the cosmic velocities of meteorites. Perhaps it would be a good guess that the impact-flashes of lunar missiles will be between stellar magnitudes of ten and fifteen. We are thus not apt to be able to observe them against the sunlit parts of the lunar disk, though it is true that chances are a little better against the dark *maria* than against the brighter lunar regions; we must rather expect to see them only against the earthlit parts of the Moon and only within five or six days of new moon, because of glare from the illuminated portion at other phases. Within these limitations, systematic searches for missile impact-flashes are certainly worth while.

The impact of a missile will presumably raise dust from the lunar surface; and observations of this dust-cloud may be very valuable for getting information about the layer of dust upon the lunar surface.[6] In the essential vacuum existing there particles of dust will fall as rapidly as any other objects; the distance s in ft. fallen by a body starting from rest will be about $2{\cdot}7\ t^2$, where t is the time in seconds. Thus we should have:

t	s
10 sec.	270 ft.
20 ,,	1,080 ,,
30 ,,	2,430 ,,
60 ,,	9,720 ,,
2 min.	38,880 ,,

The thing to note is the rapidity with which the dust would settle. Particles thrown almost 40,000 ft. above the surface would be back to the surface in only two minutes. Impact-caused dust-clouds will be brief affairs. They may very well go unrecognized by anyone not familiar with the lunar region in which they occur, especially if the initial impact-flash is not remarked. Though the impact-flash will be more likely to alert the observer when it occurs on the earthshine, the feebleness of the lighting will probably rule out any observations of consequent dust-clouds there.

We may also wonder whether the impact of a missile will alter the Moon in any detectable fashion. The resulting impact-crater is almost certain to go unrecognized, at least for the early lunar missiles; for these will surely not create new craters more than some hundreds of feet in diameter. The best lunar photographs yet taken show craterlets down to about half a mile in diameter, according to Dr. Dinsmore Alter.[7] Of course, our photographic coverage of the Moon is necessarily extremely scanty for craterlets half a mile in diameter; and certainly no existing map of the Moon is complete for all craterlets one mile in diameter, or maybe even twice that. Thus the missile impact-crater will never be realized to be a newcomer to the lunar scene, with one probable exception: if the impact-flash and/or the dust cloud have been pinpointed accurately, then a crater at that exact position much brighter or much darker than its environs may be detected, even if far too small to be resolved as a crater. Dr. Alter has estimated that a very bright spot only 100 ft. across on a dark *mare* floor would be photographable.[7] Lacking such pinpointing, the feature could not be known to be new or unusual.

It is possible that an artificial mark might be made on the moon of sufficient size to be visible from the Earth. Since the Moon lacks natural bright colours like red, blue, or green, a coloured stain would be readily recognizable if as much as half a mile across, maybe even much less under good conditions. It is not known that plans exist thus to mark the Moon, though there were unconfirmed rumours of Russians intentions in this direction in the autumn of 1957.

With these possibilities in mind the Association of Lunar and Planetary Observers, of which I am founder and director, is organizing a Lunar Missile Survey project. Some dozens of observers have already been registered, and these include a number of groups of from 2 to about 20 people. The procedure is to assign each participant a section of the very detailed 300-in. map of the Moon by Dr. H. P. Wilkins.[8] The observer then undertakes to learn the aspect of this region under all solar illuminations and in this fashion will become able to recognize artificial alterations of sufficient magnitude. Occasional practice-sessions are called, but each observer may also study his section on additional nights as he sees fit. To achieve complete coverage of the Moon we need many more observers, and we need them very widely distributed in longitude over the whole Earth, if the Moon is to be kept under constant surveillance. The help of people already knowing the Moon and of people outside of the United States will be especially valuable. Though desirable, a large telescope is not essential in this study; and we shall welcome the help of those having instruments only 3 or 4 in. in aperture.

Mr. John D. Bestwick is organizing a similar project in Great Britain,[9] and British observers may reasonably prefer to work with Mr. Bestwick's group rather than with one thousands of miles away. It will not matter, for the two groups plan to co-operate closely. What is important is that British and American observers working together can here greatly extend the effectiveness of our watch for lunar missiles and their effects. This study, we think, can be most rewarding. Even if moon rockets fail to materialize soon, systematic examination of restricted lunar regions may well increase knowledge of the Moon, which will be man's first conquest in space.

[*Continued on page* 21

Out and Around

By ORBITER

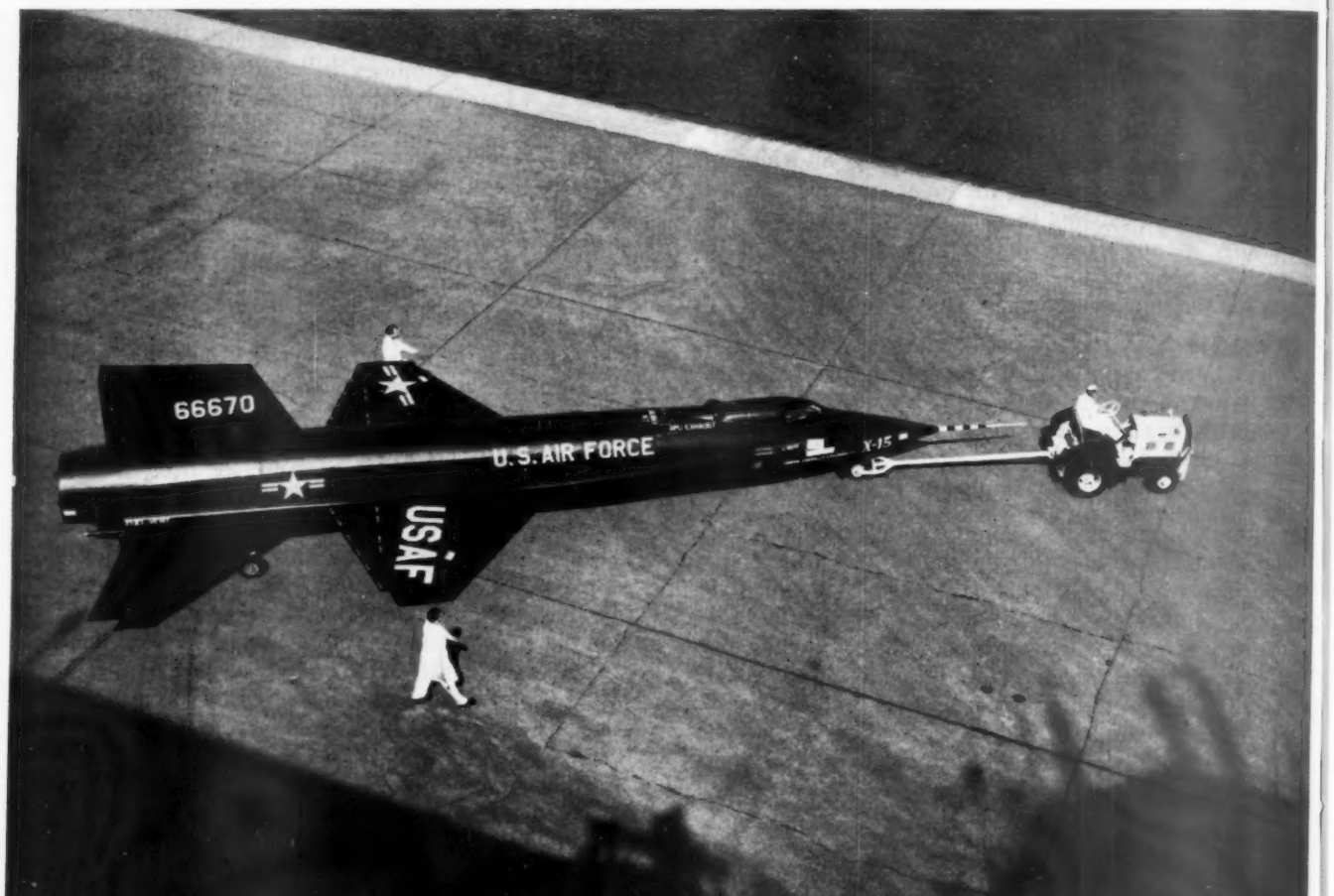
In this new series of articles, "Orbiter" will look at some of the developments in astronautics now going on. Here is his first survey

Up and Down

The Russians lanched their Sputnik I to a height of 300 miles at a speed of 18,000 m.p.h., and it stayed up three months. The Americans launched their first Pioneer Moon rocket at a speed of nearly 25,000 m.p.h.; it reached a height of 80,000 miles—and then fell back to Earth is less than a day. This apparent contradiction has puzzled many people. What is the explanation? The answer is that the Sputnik stayed up because, towards the end of its launching, it was turned into an orbit *parallel* to the surface of the Earth.

Then the Earth's gravitational pull trying to tug it down was exactly balanced by the satellite's centrifugal force trying to make it flit off into space. A good analogy is a conker whirled on the end of a piece of string.

America's Moon rocket, on the other hand, was fired straight up, and its initial speed was not quite sufficient to enable it to overcome the continual retardation caused by Earth's gravity.



X-15 = 3,600 @ 100 *Photo by North American Aviation Inc.*

Here it is—the first official photograph of the North American X-15, taken when it was rolled out in Los Angeles on October 15. A research vehicle of the first magnitude, the X-15 is designed for speeds of up to 3,600 m.p.h. and altitudes of 100 miles. It should provide invaluable data on the re-entry problems associated with manned spacecraft. On behalf of the readers of SPACEFLIGHT, I wish it—and all who fly her—happy landings.

The Hill of Gravity

When cycling, you must have often put on a spurt and then "free-wheeled" up and over the brow of a hill. You will know how if you do not start climbing fast enough you will gradually slow down, stop—and then run backwards. To get over the top, your speed has to be just that little bit greater than the retarding effect of the hill—that is, of gravity.

The same principle applies to Moon rockets. As soon as the motor ceases firing, the rocket commences to slow down. But, the further away from the Earth it travels, so gravity is that little bit less. The secret is to ensure that the rocket's speed is always in excess of the loss caused by gravity. The initial speed required to ensure this is known as the "escape velocity".

It will *not* take a rocket *beyond* the Earth's gravity. Theoretically, this influence extends to infinity, but as it falls off at a rate inversely proportional to the square of the distance (double the height, and gravity goes down to a quarter) at a distance of a few hundred thousand miles it is almost negligible and for many practical purposes can be ignored.

The escape velocity is the speed which will never quite be reduced to nothing by gravity, so that once a rocket has attained this speed it will continually draw away from the Earth.

If a rocket can reach a height of 213,000 miles, it will pass from the gravitational influence of the Earth into the field of the Moon. It will then accelerate freely, and if it hits the Moon it will strike it at a speed of 5,200 m.p.h.

Miniature Missiles

Many readers will have noticed the scale models of missiles now available in toy shops. Two recent additions are the English Electric Thunderbird with trailer and towing vehicle, and an excellent model of the Bristol Bloodhound, complete with operable launcher.

But these morsels are nothing compared with the models available in the U.S.A. A current glossy U.S. magazine advertises a kit of parts for an "exact 1/20 scale model of the Aerobee-Hi research rocket". Claimed to have taken four years, 15,000 man-hours, and £15,000 to develop, the model "climbs 1,000 ft. at 150 m.p.h., then ejects a parachute from its soft vinyl nose cone, and lowers itself safely to earth". The model is powered by a solid propellant charge and is launched from a 42 in. all-steel tower, adjustable to 10° "for wind correction". All this—for £3!

Another advertisement was offering "scale drawings of U.S. Army Missiles". Claimed to be reproductions of official blueprints, copies were available of the Talos, Honest John, Nike Ajax and the Jupiter C satellite vehicle. Lucky U.S. youngsters—and fathers.

Red Tape

The Moscow computing centre co-ordinating signals telemetred from Sputnik 3 has now stored over 600 *miles* of tape.

U.S.S.R. observation centres have carried out over 5,000 observations of the satellite and its carrier rocket, and have taken more than 300 photographs.

Sky Diary: January to March, 1959

The winter stars are back with us again; the evening skies are enriched by the presence of Orion, the Hunter, and his brilliant retinue of attendants. Sirius, the Dog-Star, shines brightly above the southern horizon, and those who are fortunate enough to have the use of very large telescopes may like to search for the strange White Dwarf known scientifically as Sirius B, but more popularly as "the Pup". Actually, the Pup is not particularly faint; but it is so overpowered by the light of its splendid companion that it is very difficult to make out. It is interesting, too, to compare Sirius with Rigel in Orion. Rigel, with a measured magnitude of 0·15, is the seventh apparently brightest star in the sky; even so, it seems far fainter than Sirius, whose magnitude is *minus* 1·43.

Rigel is a supergiant, shining perhaps 20,000 times as brightly as the Sun (different authorities give different values). What are the prospects of planetary systems circling round suns of this calibre? We have to admit that we do not know; we are uncertain even of the way in which planetary systems are produced, though most people will agree with Dr. Harlow Shapley that planets, and moreover, inhabited planets, are likely to be very common in the universe.

To return to our own local Solar System: Mars is still conspicuous throughout the January–March period, and it is still near the borders of Aries and Taurus, but it is fading steadily, and will not be in opposition again until December 30, 1960. Venus is an evening star, reaching elongation in June, and will be well placed for observation by late spring. Jupiter reaches opposition on March 17, and until then will be officially a morning star. It is in Libra, and is unfortunately lower in the sky for northern observers than was the case in 1958; in 1960 it will be still worse placed, and observers in such places as Australia and South Africa will have to bear the brunt of routine work. Saturn does not reach opposition until June 26, and it also is well south of the celestial Equator.

There will be a lunar eclipse on March 24. The time of mid-eclipse is 20 h. 17 m., but only 30 per cent. of the disk will be covered; moreover, the eclipse will be invisible from the U.S.A., and only partly seen from Great Britain. Incidentally, the next total lunar eclipse favourably visible from Britain will not occur until June 25, 1964.

P. M.

Space Medicine Symposium

October 16-17, 1958

By A. E. SLATER

It was from the Technical Policy Committee of the B.I.S. that an invitation came to "undertake the task of arranging for lectures as part" of a Symposium on Space Medicine. Whoever was to be responsible for the other parts remained a matter for speculation, but fortunately Gordon Thompson gave much valuable help, Dr. John Guignard collected a number of first-class lecturers from the Institute of Aviation Medicine at Farnborough, including himself, and Dr. Bernard Finch and Dr. John Moyse, general practitioners in London, who also joined the Symposium Committee, provided some valuable introductions.

As far as one can discover, this was the first *international* meeting on space medicine ever held. There have been national conferences on the subject, at which a occasional foreigner has turned up; and many international meetings have been held where space medicine was discussed, but they have never been solely devoted to the subject.

First on the programme came Sqn. Ldr. T. C. D. Whiteside with a paper on "Vision and Orientation at Extreme Altitudes", a subject on which his main findings were described in SPACEFLIGHT (Vol. 1, 1958, p. 286) by Dr. Guignard. But Dr. Whiteside also had something to say about the likelihood of motion sickness becoming a major problem when space voyagers undergo angular accelerations.

The same trouble would arise at the circumference of a wheel-shaped space station which is kept rotating to provide a substitute for gravity, as Dr. M. P. Lansberg, of the Dutch National Aeromedical Centre, pointed out in the next paper. As soon as anybody turns or even moves at all in this vehicle, the superimposed rotation of the wheel produces unpleasant effects which the senses do not allow for.

As to weightlessness, Dr. Lansberg did not believe that it would prevent the position of the limbs being sensed by their owner, or that it must lead to wasting of muscles on a long voyage, and he predicted confidently that "there will not be a sensation of falling, if only because there is no way to sense in what direction falling should occur".

Dr. L. G. C. Pugh, who has been both to the South Pole and on an Everest expedition, gave a most interesting extempore talk, in which he stressed the value of comfort with a satisfying amount of food and atmospheric pressure. Austere economies, in his opinion, delayed the conquest of Everest for 30 years and prevented Scott reaching the South Pole. Two men could be carried in place of one if their food and air pressure were reduced to the minimum possible, but neither would be at peak efficiency. From this point of view there would be an advantage, of course, in taking small men in preference to big ones, or even women instead of men.

Flight-Lieut. J. C. Guignard had something to say about short-period or transient accelerations, in distinction to the longer-period excessive *g* which has been studied so much. For instance, vibrations at the rate of 1 to 100 per sec. are known to impair comfort and efficiency. Sound vibrations in the ship cannot be damped down by the surrounding vacuum. The dog in Sputnik II took three times as long to settle down after the launch as it took after being submitted in a centrifuge to the same acceleration pattern; Dr. Guignard supposed that the additional factors were noise, vibration and subsequent weightlessness.

In the afternoon we had a team from the United States Office of Naval Research, led by Comdr. G. W. Hoover, who showed a most interesting cartoon film to illustrate his thesis that a space vehicle must be a "man-machine system". This means that as much care must be given to the comfort and working conditions of the crew as to the engineering aspects. In particular, Comdr. Hoover was against making all the controls fully automatic; when unexpected situations arise and decisions have to be made, the man must make them, not the machine.

Three members of his party backed up Comdr. Hoover's thesis in more detail; they were Dr. H. E. Sheets of General Dynamic Corp., Mr. A. Mayo of Douglas Aircraft, and Mr. O. Q. Niehaus of Bell Helicopter Corp.

Working conditions for a space crew were also discussed by Dr. K. F. Jackson, of the Institute of Aviation Medicine, in the light of psychological investigations on aircraft crews made by him in the past. As an example: "the speed of moving the hand from one control knob to another and the speed of turning the knob to make corrections both increased when there were more dials to deal with"; yet the pilots themselves were quite unaware of this.

"The effects of sensory impoverishment, confinement and sleep deprivation", a subject which has only recently come to the fore in discussions on space medicine, was the title of a paper by Mr. C. Cunningham, senior psychologist at the Air Ministry. He had drawn his conclusions not only from the experiences of prisoners

of war in south-east Asia, but from personal experiments in which he deprived himself of sleep.

Apart from its effect on efficiency, he did not think that lack of sleep for long periods can do much harm, as long as the victims are not worried by fear of its consequences. As to complete lack of incoming stimuli (sound, vision, touch, etc.), it certainly leads to some queer results, but only if deprivation is almost complete. This was not usually the case with the prisoners of war, and he thought that their condition most resembled that which a space traveller would have to put up with on long voyages. The important thing is to "keep him fully occupied with as great a variety of activities as is possible, and these must seem to him to serve useful purposes".

Psychology the first day: physiology the second day. Dr. H. Bjurstedt, of the Laboratory of Aviation and Naval Medicine at Stockholm, had found that exposure of animals to more than 3 *g* for 5 min. affected the lungs in such a way to reduce the amount of oxygen in the blood, even if pure oxygen was being breathed. This is bound to lead to loss of efficiency—an effect which has not been suspected before because experiments in human centrifuges have not lasted long enough for it to be detected.

Heat balance of the body, both during a space voyage and on the surface of the Moon, was worked out by Flight-Lieut. J. Billingham, of the Institute of Aviation Medicine, in two papers. He made use of a unit called the "Clo", which corresponds to the amount of insulation provided by an ordinary suit of clothing; under normal conditions a man wearing "1 Clo" would be in radiative heat balance at rest with an air and cabin wall temperature of 25° C., or of 15° C. if he was working. These temperatures would have to be reduced by 1° and 4° respectively in a cabin air pressure of half an atmosphere. Under weightlessness, in the absence of convection, if the man kept absolutely still, the cabin wall would have to be cooled down to 2° C. for him to be comfortable.

To guard against overheating on re-entering the atmosphere, it would help if the crew were pre-cooled: but in any case a human cooling system would be needed, and Dr. Billingham suggested one in his second paper, because anyone walking on the Moon in full sunlight, wearing a pressure suit with the minimum allowable internal pressure of 160 mm. mercury, would be bound to get hotter and hotter if nothing was done about it. From within outwards, therefore, the necessary layers would be: (*a*) man's skin, (*b*) thin spacer fabric like string vest, (*c*) space in which the coolant flows (liquid or gas), (*d*) layer of insulation, (*e*) pressure-retaining layer of impermeable material, and (*f*) outer surface of suit. Even at night, a man working on the Moon's surface would need to be cooled, but it would be enough to blacken part of the suit's surface.

It was good to see in this paper a reference to the work of Harry Ross, one of the earliest members of the B.I.S., who has done more than anyone to foster the study of space medicine in the Society.

The title of the next paper, "Space transport of life in the dried or frozen state", naturally excited the Press. It was Dr. A. S. Parkes and Dr. Audrey U. Smith who described their experiments at the National Institute of Medical Research on freezing and then resuscitating animals without killing them. This is not so difficult in hibernating animals such as hamsters, but in other warm-blooded mammals the heart beat and respiration cease below 15° C., and the most dangerous period is during further cooling down to near freezing point. Mice, rats and dogs have recovered from such treatment, but the prospect of applying it to human bodies, and especially of keeping them in a state of suspended animation for long periods, is considered by the authors to be "remote", though not impossible.

An interesting finding is that frozen tissues are less susceptible to damage by radiation than when warm.

Dr. C. J. Clemedson, of the Research Institute of National Defence in Stockholm, had done some experiments on blast injury and discussed how far they were applicable to explosive decrompression, which would result from holing or failure of a cabin wall in space. In both cases the lungs are damaged and the blood circulation receives a shock; but an important difference is that in explosive decompression the amount of lung injury depends on the respiration phase, i.e., for instance, whether breath has just been drawn in or just been expelled.

Mr. S. W. F. Hanson, from the Ministry of Food, recommended dehydrated foods for voyages of a few days, such as to the Moon and back. The necessary water for reconstituting them could be recovered from that given out by the crew, so weight would be saved.

An important part of space medicine is the science of radio-biology, but it proved impossible to get any of the experts to talk on it, and least of all would any physicists talk about the newly discovered radiation belt round the Earth.

So one had to rush in where physicists feared to tread, but one point which they had all overlooked could be brought up. This belt, according to data from Explorer satellites, extends only from 30° N. to 30° S. *magnetic* latitude. The magnetic equator is inclined 11½° to the geographical equator, and that, in turn, is inclined 23½° to the ecliptic. These figures add up to 35°, and consequently once a day the plane of the ecliptic is 5° outside the radiation belt on opposite sides of the Earth. Further, the Moon's orbit is inclined 5° to the ecliptic, and the line where these two planes intersect undergoes a complete rotation every 18 years. Just now, a straight line from Earth to Moon lies wholly inside the belt. But in 9 years' time this line will miss the belt by 10° once a day. So there may just be time to by-pass the worst of it—and this belt is the most dangerous medical hazard to space-flight yet discovered.

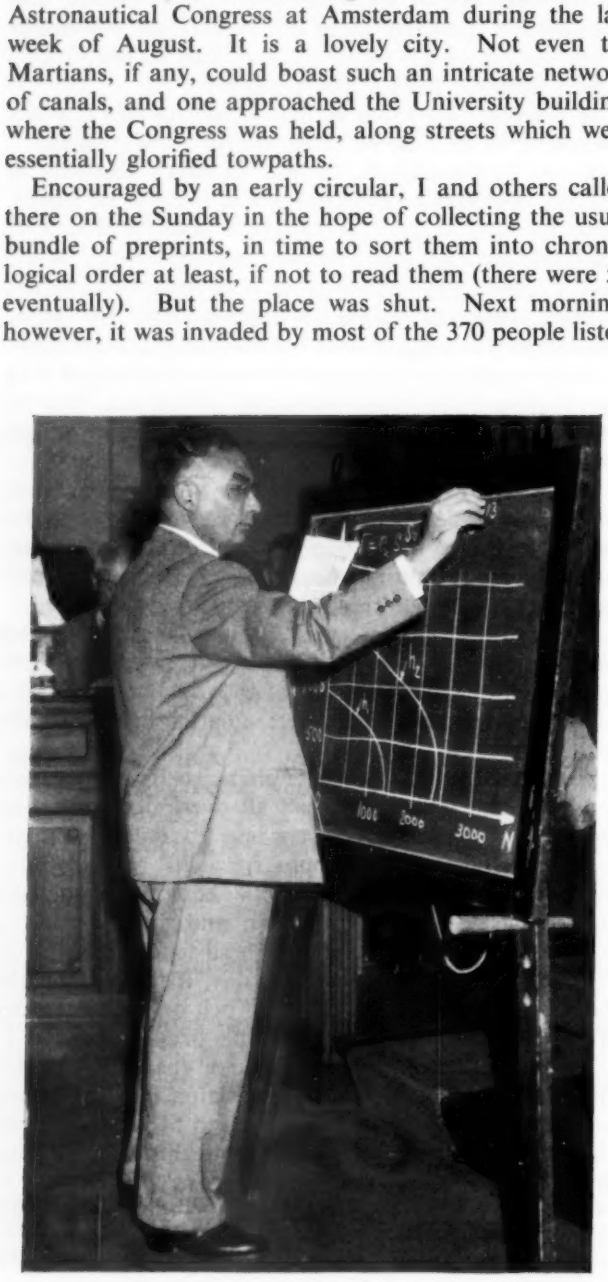
The I.A.F. at Amsterdam

By A. E. SLATER

A personal account of the Ninth International Astronautical Congress

Compared with the distance to Barcelona, Rome, Zürich and the like, a comparatively short journey was involved this year in attending the Ninth International Astronautical Congress at Amsterdam during the last week of August. It is a lovely city. Not even the Martians, if any, could boast such an intricate network of canals, and one approached the University building, where the Congress was held, along streets which were essentially glorified towpaths.

Encouraged by an early circular, I and others called there on the Sunday in the hope of collecting the usual bundle of preprints, in time to sort them into chronological order at least, if not to read them (there were 58 eventually). But the place was shut. Next morning, however, it was invaded by most of the 370 people listed as participants, who found an immense edifice surrounding three sides of a large forecourt, with, as fourth side, a cloister lined with exciting second-hand bookstalls.



First lecture after opening ceremony

The official opening was timed for 10.30, but it took longer than that for queueing crowds (one queue for each half of the alphabet) to get themselves registered, labelled, and loaded up with those precious preprints. Of the 370 on the list, the U.S.A. accounted for 133, Holland 53, Germany 36, the United Kingdom 32, France 17, Italy 12, Sweden 10, Russia 8, and the rest 5 or less, making 30 different nations in all, if you count French West Africa, Northern Ireland and Formosa separately.

A notable feature of this congress was the presence of Wernher von Braun for the first time. He had never been allowed out of America since he went there at the end of the war; but now, with all these satellites circling the Earth, he himself has been allowed to perform a partial circuit at lower level. Everyone was looking forward to a long talk by him at the opening session about the Explorer satellites. But the gallant act of bending down to pick up a lady's handkerchief proved too much for his massive frame; something went click in his spine, and he was thereafter out of action in a horizontal position until the last day of the meeting. However, at a "get together" party the previous evening he had met a lot of old acquaintances and made many new ones, including Professor Sedov, the leader of the Soviet delegation.

The chairman of the Royal Netherlands Aero Club, Mr. C. Kolff, in declaring the Congress open, reminded everybody that much time and money is wasted in doing the same research in different countries, and it was time that a world centre for astronautical research was organized. He was followed by Andrew Haley, I.A.F., president, who welcomed everybody.

Then Professor Theodor von Kármán gave the first paper on the new science of magneto-hydro-dynamics, which will apply to matter in space and replace the simple aerodynamics of primitive aircraft, so that future spaceships will be subject to what he called "heavenly turbulence" caused by electro-magnetic forces. In fact, he said, it was this sort of turbulence which originally decided the distances of the planets.

In the absence of Dr. von Braun, Prof. L. I. Sedov followed with a discourse on the many perturbing influences on the motion of Sputniks. Among these is an increase of atmospheric density at 225 km. altitude

Andrew Haley (I.A.F. President for past year) and Dr. Kooy, President of the Dutch Society which organised the Congress; also, furthest right, Dr. von Braun

when night gives place to day; evidently the whole upper atmosphere is raised through being heated at lower levels.

All this happened in the big hall of the university, after which we adjourned to the ordinary lecture rooms. Since there were at least 80 papers on the programme, two of these rooms had to be used simultaneously, and the general arrangement was to have papers on propulsion technology in a lecture room upstairs, and everything else downstairs. Not being a rocket engineer, of course, I spent most of the time on the ground floor, but even at that, it is impossible even to summarize in the space available all that went on, and in this account a minority of lectures will have to be picked out, to the exclusion of the rest.

Almost the first paper downstairs was a sobering one by Dr. J. Jongbloed, Professor of Physiology at Utrecht University, who asserted that modern rockets have as little to do with human travel through space, meaning the attainment of a destination followed by a safe return, as Otto Lilienthal's glider had to do with air transport. The medical problems, he warned, would be far more difficult than those of aviation.

Meanwhile, upstairs, photon rockets were being discussed by Dr. Eugen Sänger and one of the three British papers at the congress was being given by the B.I.S. chairman, Dr. Leslie Shepherd, of Harwell. "Electrical propulsion systems for space flight" was his subject, and he showed that, to get practical results, particles must be accelerated electrically to a speed of at least 100 km./sec., and must give the vehicle an acceleration of at least 1 *g*. His idea of the ultimate form of such a system was "a closed-cycle plasma generator coupled to a magnetic plasma accelerator". And plasma, these days, does not merely mean a convenient substitute for a blood transfusion, but can also mean a homogeneous conducting fluid made up of protons and electrons, as Dr. von Kármán had already explained.

In the evening the Municipality of Amsterdam laid on a reception at the National Museum.

Tuesday morning, August 26, was notable for a brilliant paper by Dr. S. F. Singer, now at the University of Maryland, on the newly discovered radiation belt which has been revealed by the Explorer satellites. His paper is being published in the B.I.S. Journal, so not much need be said here about it. His theory is that this radiation belt consists of protons trapped in the Earth's magnetic field at heights above about 1,000 km., and that their greatest concentration should be at one-and-a-half Earth diameters (just under 6,000 miles) above the geomagnetic equator. Since he wrote the paper, the "Pioneer" Moon rocket has registered the greatest concentration at 5,700 miles, so it looks as if Singer's explanation may be right. His most astonishing claim was that almost the whole lot of protons could be swept up in a month by a dozen large-sized satellites designed to absorb them, because new protons are injected into the belt at an extremely slow rate. Surely Fred Singer must have got this idea from Lewis Carroll's "seven maids with seven mops".

Interplanetary trajectories received attention in the afternoon, first by T. A. Magness, of Ramo-Wooldridge Corp., U.S.A., who pointed out that, for routes to Mars or Venus requiring more than the minimum energy, the accuracy of guidance up to the time of rocket burnout can be very much less than that needed for a minimum-energy trajectory. And W. E. Moeckel, also from U.S.A., had worked out that round voyages to Mars and Venus and back, other than by minimum-energy routes, can be so shortened that the weight of additional fuel needed is more than offset by the weight of stores saved. The standard minimum-energy round trips of 760 days to Venus and back, and of 973 days to Mars and back, could each be advantageously shortened to 400 days.

In the late afternoon the Amsterdam Municipality laid on a delightful boat trip through the canals—but it was not for those who had to send despatches about the day's lectures to London newspapers.

The case for solid-fuel rockets for some purposes was put on Wednesday by Kurt Stehling, of the U.S. Naval Research Laboratory. Liquid rockets cannot be scaled down without detriment to their mass ratio; solid rockets, on the other hand, cannot be scaled up without running into difficulty, but they have the advantage of being more easily kept in a state ready for firing.

Wednesday's most spectacular show was a film made by Dr. H. von Beckh, taken in an aeroplane while flying on a parabolic course in order to produce weightlessness in its occupants. One man was shown trying to feed himself. First, he put a glass of water to his lips, but outsize drops floated away in all directions. Then he tried squirting water into his mouth, but automatically raised his weightless arm too high. Then he got his teeth into some dried food and managed to swallow some, but large chunks broke off and glided gently away.

Usually, people subjected to weightlessness by this means have to suffer excessive *g* as the aeroplane pulls out of a preliminary dive into the upward leg of the parabola; but this time they were given just as much *g* after the weightless period as before, and it was found that the excessive *g* was then much less well tolerated. This must mean that, when descending to a planet's surface with rocket braking after a weightless voyage, the amount of deceleration the crew can tolerate must be less than the acceleration they can stand during take-off.

Another novel experiment by Dr. von Beckh was to deprive a man of sleep for 48 hours, then put him into the aeroplane and allow him to fall fast asleep. As soon as he entered the weightless parabola, he woke out of his deep sleep with an uncomfortable feeling that his arms and legs had "floated away into space". Here is another psychological effect of weightlessness to add to the troubles already forecast.

Another interesting Wednesday paper was by Dr. Fred Whipple, of Harvard University. He wants to instal a telescope in a satellite for photographing the sky in ultra-violet light of a wavelength which never penetrates to the lower atmosphere. The sky, photographed in such a wavelength, would look surprisingly different from the appearance we are used to seeing here below, and he would have the photographs radioed to Earth by television. He proposed a reflecting telescope of 8 in. aperture and 2 ft. focal length, and was convinced that the scheme would be feasible within two years.

Thursday was Andrew Haley's great day. He had organized a Colloquium on Space Law at the House of Parliament at The Hague, and in starting the debate with a list of problems needing to be settled, he made the comforting remark that the newly discovered radiation belt might well make impracticable the sort of "invulnerable bombing platforms" which had been proposed for putting into circulation in the region of the belt. Many papers from various countries were read, and the colloquium ended with the passing of three resolutions: one was for a new International Convention for settling the relevant legal problems; another was for a Legal Permanent Committee consisting of legal experts from I.A.F. affiliated societies; and the third was for assuring the Secretary-General of the United Nations of the readiness of the I.A.F. to co-operate in any initiative taken in the field of astronautics.

For those who kept away from Parliament and the Law, there was an excursion to Rotterdam, which included a visit to the Shell refinery at Pernia, a boat trip through the docks, a bus tour to see the reconstruction and town planning, and a reception in the Town Hall by the Municipality. (I had to miss it all for the usual reasons, but by all accounts it was something nobody ought to have missed.)

Back to our desks on Friday, we heard the second British paper, given by R. H. Merson of the Royal Aircraft Establishment at Farnborough. He described how the R.A.E. analyzed the orbits of the various Sputniks, his particular job being in the computor section where predictions are made. It was rather suprising to hear that single visual observations by amateur and professional astronomers were found more useful than fixing a satellite's position by triangulation, using simultaneous theodolite observations or photographs taken from various parts of the British Isles; in fact, only one really good triangulation was secured. One problem that needs solving, according to Mr. Merson, is that the rate of decrease of the orbit's inclination to the equator, believed to be caused by the rotation of the Earth's atmosphere, is 30 times what would be expected.

Two people on this day wanted to send probes to the Sun and Moon respectively. R. P. Haviland, of General Electric, proposed making up a five-step vehicle with present-day rockets, two liquid-fuelled and three solid-fuelled. The whole set-up would weight 250,000 lb. at take-off and be able to "place" a 50-lb. probe as near the Sun as the orbit of Mercury, in order to investigate the Sun's atmosphere (it is considered now to extend beyond the Earth). An interesting feature of this paper was a list of items of equipment showing the highest temperature each could stand. For instance, semiconductors could get no nearer the Sun than Venus unless kept in the shade. This could be done by using a cone-shaped container with its base kept facing the Sun automatically, so that its sides would be continually in shadow.

The Moon probe, suggested by Alessandro Boni, of Italy, was a very different proposition. It would relay photographs by television up to the moment it hit the Moon, and most of the paper was taken up with discussing the maximum fineness of detail which photographs could be made to show with suitable optical apparatus. The conclusion was that details 1 cm. wide could be televised from 2 km. away, and the final picture before impact on the Moon would be taken 2 metres away and show detail to a hair's breadth.

Describing results from the Vanguard satellite, Mr. J. W. Siry said that its perigee was over the Earth's equatorial bulge, and consequently air resistance was at its greatest because there the Earth's surface comes up to meet the satellite, and so does the overlying atmosphere.

On the other hand, at much greater heights the atmosphere is densest over the Poles, according to Prof. V. I. Krassovski, of Russia, because it extends farther out into space there, as Sputnik III revealed. This satellite registered impacts of 15 micrometeorites per sec., which, an American pointed out, was more than 1,000 times the frequency found by his own country's satellites. Prof. Krassovski replied, through his interpreter: "I can't do anything about it."

Another Russian contribution, given next day, was from Mr. K. F. Ogorodnikov on "Optical observations of artificial Earth satellites". He said that present satellites were too faint for their position to be plotted with an accuracy needed for geodetic research, such as finding the distances between continents, or the exact shape of the Earth, with accuracies of the order of 10 metres, compared with present uncertainties which are of the order of 100 metres. So the Soviet Astronomical Council has considered furnishing future Sputniks with light signals which would flash intermittently as they pass over at night.

Terence Nonweiler, who read the third British paper, returned to the attack on his favourite "re-entry" problem. This time he had worked out that, if you use parachutes or similar braking devices, you cannot avoid having to put up with a maximum deceleration of about 8 *g* at one stage of your descent, however large the area

of your drag device. He also recommended that the descending vehicle should be of low density to avoid overheating; a sphere with a specific gravity of unity would heat up to about 1,500° C.

A most original paper came from Dr. T. C. Helvey, though unfortunately written in the same thick verbal style of its title: "Problems of ground simulation of long range space-flight environmental conditions". He has designed the required "ground simulator", though not yet built it, at Radiation Inc., Florida. He prophesied that "within 10 years the miniaturization and reliability of electronic gear will have been developed to a degree where most of the equipment can become, dynamically and statically, a structural part of the space frame", and he had carried this weight economy so far as to design a human anti-radiation suit in which the thickness of the shielding varies according to the susceptibility to radiation of the underlying tissues. The brain, he said, "does not need much protection".

The big event of Saturday morning was Prof. von Braun's lecture, his doctor having allowed him to resume the vertical position. The great hall of the university was once again crowded. Mr. A. H. Hibbs shared with him the telling of the story of the Explorer satellites—how No. 1 discovered the radiation belt, No. 3 showed that it increased in intensity with height (and incidentally, this satellite, had its telemetering apparatus put out of order by a meteor stream which follows the path of Halley's Comet, misprinted "Haley's comet" in the text); and how No. 4, instrumented solely to explore the belt, was launched at 50° to the equator so as to determine its boundaries. No. 5 went wrong because residual gases in the booster, after its separation, pushed it forward again so that it collided with the guidance compartment.

Wernher von Braun concluded: "This little planet, which people once were wont to call 'the world' but which our satellites now circle in 90 minutes, has become too small for war and strife."

What happened on Saturday afternoon I do not know, because there was just time to visit the Dutch national gliding centre near Arnhem between the last lecture of the congress and the first course of the farewell dinner. As to the latter, I sat next to the most interesting and entertaining companion I have ever had at an astronautical dinner—Frau von Diringshofen, wife of Dr. H. von Diringshofen, who made the first experiments on weightlessness in an aeroplane, some 20 years ago.

The Netherlands Association for Space Travel took on a big task in organizing such a congress, but nobody could have regretted attending it. There were some criticisms of the organization, but the chief trouble I found was due to the arrangement for simultaneous lectures on two floors. Firstly, it was difficult to keep track of what was going on in both places, and, because the time-table was not strictly observed, one could miss a lecture one particularly wanted to hear. Secondly, one could go for days without seeing somebody one wanted to meet.

But this trouble may get worse with time. I have just heard, in "Science Survey" on the radio, of a recent International Congress of Biochemistry at Vienna where there were 1,700 papers read and 24 lecture rooms in use simultaneously. The I.A.F. is well on the way to achieving the same state, at the rate things are going. But perhaps, by that time, we shall all be able to sit at home and attend the congress electronically.

THE RUSSIAN "LUNIK"

The first days of 1959 were marked by yet another major step in astronautics. Russian scientists successfully launched a vehicle which passed within 5,000 miles of the Moon, and subsequently entered an orbit round the Sun, so becoming the first artificial "planetoid". Appropriately enough, it has become known as the Lunik.

The news was received only just as this issue of *Spaceflight* was going to press, but details—so far as they are known—will of course be given in our next issue. Meanwhile, everyone will wish to add their congratulations to the Russians upon this great new achievement, which ranks with their classic success with Sputnik I less than eighteen months ago. THE EDITOR.

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have believed. Just what the outbreak will tell us, remains to be seen; but at any rate Kozirev's skilful work has opened up some new avenues of research.

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Anyone desiring further information about this observational project or wanting to help with it is invited to write to me at 1835, Evans Place, Las Cruces, New Mexico, U.S.A.

My thanks go to Editor Patrick Moore for his kind invitation to contribute this article to SPACEFLIGHT.

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News Diary

By PETER BAILY

7 *September*. Black Knight, the British single-stage liquid fuel research rocket, went 300 miles straight up on its first flight test at Woomera today. This may not seem a very impressive feat. Other rockets have worked first time. Other rockets have got higher. On the 27th of last month a single-stage Russian rocket carried two dogs to a height of 280 miles—and brought them back alive. But the news caused tremendous interest in Britain. To many people Black Knight proved that anything America and Russia can do, we can do better. The fact that the rocket had reached "satellite height" was frequently mentioned, the fact that it had reached it at zero velocity instead of 18,000 miles an hour was not. But even if the wish appeared to be father to the thought in much of the comment, at least it was plain to see that the wish (for Britain to do something worthwhile in space research) was widespread. Black Knight was developed in 2½ years at a cost of £5 million, and today's test firing is the first fruit of the Black Knight-Blue Streak development programme briefly reviewed in our last issue. As stated then, Black Knight is meant for research on warhead re-entry problems.

9 *October*. "It is our plan to have a man in space inside 24 to 36 months," said Roy Johnson, head of the Advanced Research Projects Agency, in a speech at Stamford, Connecticut, last night. Pentagon officials today hint that this may refer to the X-15, the stainless steel rocket-powered research aircraft under development at Los Angeles.

13 *October*. The eyes of the world today were on Pioneer I as it soared further out into space than man has ever reached before, and then began to fall back, after getting a third of the way to the Moon. The second of the U.S. Air Force's three shots at the Moon, Pioneer was up aloft for 43 hr., reached a distance not far short of 80,000 miles, and radioed back some interesting data before falling into the Pacific today.

Pioneer received a radiation dose of 50 roentgens on its trip: atom workers are not allowed more than 15 a year. Most of the radiation is believed due to electrons trapped by the earth's magnetic field, forming a belt ranging from 250 to 20,000 miles out.

Temperature inside Pioneer fell from 71 deg. F. to 41 after 3 hr., then stabilized at 35 to 36 deg. F. This is colder than was expected, and may account for failure to work of some of Pioneer's gadgetry, notably the retro-rockets and the picture transmission gear.

15 *October*. The U.S. Air Force today disclosed that in addition to its third shot at the Moon next month it has been authorized to launch two more space probes, one probably aimed at Venus. Probable date for blast-off: next summer.

19 *October*. Widespread comment in the press and on the air was attracted by the B.I.S. Symposium on Space Medicine, held on 16 and 17 *October* at the London headquarters of the British Medical Association. Today the *Observer* had this to say: "Plans for three year cruises to Mars and 100 mile wide mirrors in the sky have been largely replaced in the (B.I.S.) proceedings by abstruse excursions into rocket engineering and fuel chemistry. . . . Some learned circles are not willing to accept the promotion of interplanetary travel as a proper objective for a sober scientific institution. The society's answer is that the eccentricities of two decades ago are turning out to be sound sense today."

Dr. Robert Dietz of the U.S. Office of Naval Research told a *Sunday Times* reporter last week: "It's a sobering thought that man has seen more of the surface of the Moon than he has of the surface of his own planet. And yet the Pacific sea floor alone has an area five times that of the Moon." Trial dives in the deep sea bathyscaphe *Trieste* will begin soon off San Diego, and, says Dietz, "We will be extracting minerals from the Pacific floor long before the first rock is brought back from the Moon."

20 *October*. Britain is "visibly the most advanced in the field of space technology" of European nations, says a report issued in Washington yesterday by the House Committee on Astronautics and Space Exploration. "They have developed the Black Knight missile which could be used to launch a satellite or in conjunction with another missile, the Blue Streak, to place as much as half a ton in orbit." So the report says anyhow, going on to praise Defence Minister Sandys for his "positive interest" in space travel.

8 *November*. The third and last U.S. Air Force attempt to shoot the Moon misfired today. At 7.30 a.m. today our time Pioneer II lifted off the launching site at Cape Canaveral. Hopes were high as the 88-ft. three-stage Thor-Able rocket with its 85 lb. payload roared away into the sky, but the third stage failed to fire. After reaching a height of 1000 miles the rocket fell back and burned out somewhere over East Central Africa. The first attempt on 17 August ended with the rocket blowing up after 77 sec. of flight, and the second attempt on 11 October was also a failure—but, according to one writer, the "most glorious, even successful, failure in scientific history". Now it is the turn of the U.S. Army, who may make their first attempt next month.

The failure of Pioneer was due to a slight timing error in the firing programme, which resulted in a 3½ deg. aiming error and the loss of 400 ft./sec. of the required velocity. Pioneer II and the un-named first attempt in August failed due to faults developing in the rocket engines. Although it did not get to the Moon or send back pictures of the far side, Pioneer did stay up 43 hr. and reach a height of 79,212 miles, and it remains to be seen if the Army can do better.

Meanwhile Corning Glass Works have put on sale in a Manhattan department stores oven dishes in Pyroceram, a new heat-resistant glass that looks like china. The dishes are heated red-hot by acetylene torch, then plunged into ice water by way of demonstration. Pyroceram's original use is more exacting still, however. It was developed by Corning's fundamental research department as a rocket sheathing, and the Pyroceram nose cone for guided missiles was demonstrated less than two years back; a quick beating of swords to plough-shares.

11 *November*. Arthur C. Clarke joined a discussion which has been going on for days in the *Daily Telegraph* correspondence columns about radio and T.V. propaganda, with a letter printed today under bold headlines: "Satellite-borne TV? Worldwide chain could be set up". Clarke quoted Von Braun's recent testimony before the House Select Committee on Astronautics and Space Exploration about commercial uses of satellites, "as a link for global television" and as a means for sending telegrams. Clarke concluded as follows: "Should any one nation establish a satellite relay chain it would do more than dominate the world's communications. The cultural and political impact of TV news and entertainment broadcast directly to every home on Earth can hardly be over-estimated.

"When one considers the effect of TV on ostensibly educated populations, the impact on the semi-literate peoples of Africa and Asia may be decisive. It may well determine whether Russian or English becomes the leading world language by the end of this century. Those ill-informed critics of space exploration projects who appear to consider them wasteful scientific stunts which we should leave to other countries may like to ponder the fact that the communications satellite is merely the first, short-range application of the science of astronautics to human affairs."

12 *November*. Persistent reports that Britain may soon have her own space programme have preceded the Royal Society's Conference on Space Research, which opens in London today. Reports stated that Prof. H. S. Massey, chairman of the conference, had advised the government that a four-year, £60 million programme should aim to launch a British satellite by means of the Blue Streak rocket. The programme, running concurrently with the Ministry of Supply development of Black Knight and Blue Streak for defence purposes, would not just duplicate American and Russian work in the field but would attempt to carve out a distinctive British niche in space research, possibly specializing in the problems of satellite re-entry, satellite-borne TV gear and recording equipment. Later the Royal Society said that it had never been asked for its opinions in the shape of a formal report. Naturally the Ministry of Supply was in touch with the scientists on the Rocket and Artificial Satellite Sub-committee of the British International Geophysical Year Committee. Prof. Massey, who is also chairman of the Sub-committee, was asked about the report and said: "It's entirely guesswork, and like most guesswork it's off the beam." General opinion is that there's no smoke without fire, but the government may not make a final decision until the budget estimates for next year are prepared.

13 *November*. Points raised at the Royal Society's Space Research Conference held in London yesterday and today, included the following. Many scientists interested in space and the planets have still not caught up with the tremendous strides made recently by the rocket engineers. According to Prof. T. Gold, of Harvard University, the one real discovery made by the satellites is the radiation belt which surrounds the earth, and this was due to the fact that a man was ready with the right instrument and it worked. There are many other problems which satellites will be able to investigate—when the experiments have been designed and the instruments are ready. He thought it would be better to send a crude instrument for a close look at Mars and Venus rather than to put up a very well instrumented Earth satellite for a distant look at them. On the other hand, Prof. Fred Hoyle, of Cambridge University, said that a satellite carrying a 20-in. aperture telescope "could be extremely useful". It could scan wavelengths which did not reach the earth's surface due to absorption in the atmosphere and thus give valuable information in connection with the evolution of stars. Prof. A. C. B. Lovell's paper referred to the limitation placed on the observations at Jodrell Bank by ionospheric absorption of low frequency radio waves, and pointed out that a radio telescope out in space would not only be free of this restriction but would also be shielded by the ionosphere from the incidental radio interference which was such a nuisance on Earth. Prof. J. Van Allen, of Iowa State University, discussed the Earth's radiation belt. Apparently incoming particles were trapped by the Earth's magnetic field and held prisoner for about a month. Possibly most of the cosmic ray particles reaching Earth originate in the Sun, their original direction of travel being completely lost during their trapping. The very high energy cosmic rays are still believed to come from the remoter parts of the universe.

14 *November*. Biggest talking point in astronomy this week is the Russian claim to have seen and photographed a volcanic eruption on the Moon. Nikolai Kozyrev made the observation on a 50-in. mirror telescope at the Crimean observatory on 3 November, and Tass issued the report the day before yesterday. The eruption is said to have occured in the 60-mile wide crater Alphonsus. Nobody else saw it and the crater will not be in sight again until next Friday. Comment ranges from scepticism to enthusiasm, although most astronomers are agreed that the Russians certainly saw something. Prof. T. Gold thought the Russians might have seen a gas escape lit up by the Sun's radiation, and believed they had drawn the wrong conclusions from whatever they had seen. Prof. Fred Hoyle said he'd like to see the photographs before committing himself. He didn't think a lunar volcano at all likely, but there might have been a meteorite. Prof. Alexander Mikhailov, chairman of the Astronomical Council of the Soviet Academy of Sciences, said: "We can now regard as completely unfounded the existing view of the origins of (lunar craters), which ascribes them to the fall of meteorites. The volcanic eruption shows that the Moon shares similar processes to those responsible for the formation of Earth's mountains." This is generally thought to be pitching it a bit strong.

In the U.S.A., Dr. Wernher Von Braun's U.S. Army team think the odds against success in their first Moon shot, scheduled for early December, are only 2:1. This compares strikingly with the 25:1 odds on failure which the U.S. Air Force quoted for their attempt last month. The Army will use a more powerful rocket and will only try to hit the Moon, not circum-navigate it. Von Braun's men seem confident that they will repeat the success they had last February when they put the first American satellite in orbit after the Navy's failures with Vanguard.

15 *November*. Space research and space law are fast becoming a preferred area for political manœuvre. The political committee of the U.N. General Assembly has before it proposals from the two countries with advanced space-going projects. The Russian proposal links a ban on the use of space for military purposes with the elimination of foreign bases on the territories of other countries. The American proposal omits any reference to foreign bases but also advocates the peaceful use of space on the grounds that "the exploration and eventual exploitation of outer space will affect the life of every human being. Moreover, the nature and immensity of the challenge facing us and the interest it holds for scientists make it clear that activities in outer space . . . must be carried out with the appropriate international co-operation within the framework of the United Nations". Fine words, with which few B.I.S. members will quarrel. Most space research so far has been a by-product of weapons research, and the only people with money to spend on the big rockets have been the defence chiefs, whose interest has been in sending bombs, not people, on long fast journeys. Maybe now the "space race", with its unsuspected opportunities for prestige, will change all this.

Yet another scientific organization which has decided to interest itself in space research is the International Council of Scientific Unions, which decided at its eighth annual general meeting in October to set up a space research committee. The committee, comprising nine union men and representatives from all countries which are either probing into space or tracking other people's probes, held its first meeting in London yesterday and today. The object of the meeting was first to decide what purpose the committee could serve and second to draft a constitution. British representative was Prof. H. S. Massey, newly converted astronautical enthusiast, who also took the chair at the Royal Society's Space Research Conference earlier this week. Prof. Massey, of University College, London, a fifty-year-old Australian, is believed to be one of the

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Of Academic Importance

By ALICE COLEMAN

Miss Coleman, who has recently spent several months in the United States, describes how the satellite launchings have affected the American educational outlook

Little more than a year ago public opinion regarded the launching of an artificial satellite, if indeed possible at all, as purely "of academic importance". It was felt that even a manned voyage to the Moon would leave the ordinary rank and file of humanity completely untouched in the practical conduct of their lives.

Yet the impact of the Sputnik is already changing the lives and outlook of millions of Americans in a very practical everyday affair—education. Shocked and humiliated by being left at the post with a series of flopniks, while the Russians raced ahead to inherit the world admiration scheduled for the U.S.A., the Americans have turned a searchlight of seething query on to the quest for the shortcomings which led to their national disgrace. As a man coming out of a rosy daydream may retrospectively hear for the first time a remark addressed to him minutes earlier, so the Americans now began to respond to lone voices in their midst which had gone unheeded for at least a couple of decades. These prophetic cries that American education had become so diffuse and diluted that its products would not be able to compete with the scientific manpower of other nations, were now suddenly perceived to be stark truth. They were listened to, echoed, and finally embraced, in a stream of speeches, legislation and dollars set fair to cement an entirely new cultural climate.

A year ago educationalists were stressing that "social adjustment" was of far greater value than academic achievement. Indeed, a schoolboy's reward might well lie in marking time: not only was it anti-social to "get ahead of the others", but this might even land him the invidious distinction of an alpha mark and place him in the egghead category. Tales were told of children who begged the teacher quickly to replace an alpha with a beta mark before their classmates should discover their possession of undesirable brain power. As the author John Dos Passos has recently said, "For the last 25 years we've been educating people to discredit brains."

The Russian Sputniks have made a big dent in all this. Education is now a live issue, and many and varied are the formulæ for its improvement. Teachers were raised in status almost overnight from no-account underdogs to the hope of the nation's salvation, and that hallmark of American status, the increased salary, was proposed on all sides. Teachers' salaries have certainly been pitiably low hitherto. In Baltimore, for example, over 850 teachers, one-third of the total, were uncertificated because salaries were too low to attract qualified people. Indeed, they were too low to attract people to become qualified. The University College of Los Angeles Office of Teacher Placement received during 1956–7, 616 requests for teachers with backgrounds in mathematics, but was able to provide only seven graduates willing to consider teaching as an alternative to more lucrative industrial posts.

President Eisenhower has proposed federal aid to education to the extent of a thousand million dollars over the next 4 years, and strings attached in its allocation are designed to prod out of the individual states another six hundred million in matching funds. Senator Kennedy introduced a bill calling for $1,500 million for new school construction over a 5-year period, while Mr. Marion B. Folsom, Secretary of Health, Education and Welfare has detailed a $74 million programme to meet the shortage of college and university staff. The separate states are also voting large sums to education, and those which do not are roundly criticized in the press. Big grants from private foundations have also made news on the educational front.

But even the mighty dollar cannot take care of everything, and there is much stress on the quality and content of curricula. Dr. Milton S. Eisenhower, president of the Johns Hopkins University, has laid great emphasis on the need for quality. Noting that European school-children "achieve scholastically in 10 years what ours do in 12", he has advocated increasing the academic load of all pupils. One proposal which is currently practised in very few states, and is quite revolutionary in U.S.A., is that the brightest children should be given more advanced work suited to their abilities. This entails their segregation in separate classes or divisions from the mass of the school population, a suggestion hitherto repulsive to American ideas of democracy, but now indicated by the Sputnik as a necessity. A further approximation to the British system has been proposed by Rear-Admiral Rickover, inventor of the atomic submarine, namely that America should establish a national standard of academic excellence in schools by means of a diploma somewhat comparable to our General Certificate of Education. The National Association of Secondary School Principals has recommended that science and mathematics should be required courses from the age of 12 plus onward for the more gifted children, who should be identified not later than this age. The remainder of the school population should receive one year courses in science and mathematics at about the age of 16. These subjects are being spotlighted at present, but there is also a demand for more language teaching, especially Russian, and

most other academic subjects are sharing in the advanced status of education as a whole. Scientists' speeches frequently include responsible statements on the need for a balanced education giving due weight to the humanities.

Voices on the other side of the fence are also to be heard. They come, naturally enough, from public authorities unwilling to levy more taxes in the cause of education, but also, rather unexpectedly, from some sections of the educationalists. These are people who have vested interests in the *status quo*—the proponents of social adjustment training, etc., who fear that their own, often excellent, achievements may be undermined and displaced by emphasis on mathematics and natural science. They tend to characterize the surge of academic enthusiasm as mass hysteria and panic likely to lead to a dehumanized age of science. However, as even the most advanced scientific programmes yet recommended for schools will still expose American children to less science than their not particularly dehumanized British counterparts, the foriegn observer in American can see little cause for alarm. Fears might be set at rest if someone took up one newspaper's challenge and nominated a co-ed with a maths degree as "the most desirable girl of 1958".

The school and student population of America numbers 40 million and there are 1,300,000 teachers and professors. All of these stand to have their daily lives altered and enhanced as the result of the Sputniks. Thus, in the most literal and desirable sense the Sputniks have proved to be "of academic importance".

Conditions on Mars

By C. A. CROSS, M.A., F.R.A.S.

Mars is said to be more Earthlike than any other planet: but is it really similar to our own world? In this article C. A. Cross sums up what we have found out concerning the conditions which the first pioneers are likely to encounter.

Mars is in the news again. This happens regularly every 26 months as the Earth catches up with its slower neighbour in space. As the two planets come closest together, at opposition, the amateurs sit at their small telescopes to make sketches and nowadays even some of the professionals tear themselves away from their astrophysics, for Mars is once again a fashionable subject for research.

This activity is reflected in astronomical and astronautical journals, and even in the popular press. As a result of all this publicity most of us know a great deal about Mars in a superficial and uncritical sort of way. The trouble with this sort of knowledge, however, is that the popularizers are often guilty of presenting speculations to us as though they were established facts. Thus one day we read that the Martian deserts are limonite, the next that they are volcanic ash, and yet again that the dark markings themselves are volcanic ash.

In writing this article I shall therefore assume that you have all read these popular accounts, and instead of merely presenting another version of the same kind I shall try to show how our knowledge of the planet is deduced from what we actually observe. This enables us to distinguish between the well-established deductions which can be confidently accepted, and the host of conflicting hypotheses which await the accumulation of evidence before they can be accepted or rejected.

Basic Astronomical Data

In the Nautical Almanac or the B.A.A. Handbook one finds the following information about Mars:

TABLE I

The Planet Mars

	Astronomical Units	Miles	Kilometres
Distance from the Sun			
Mean	1·5237	141,500,000	228,000,000
Aphelion	1·6658	154,100,000	248,000,000
Perihelion	1·3826	128,000,000	206,000,000
Distance from the Earth			
Perihelion Opposition	0·374	34,797,000	56,000,000
Aphelion Opposition	0·662	61,516,000	99,000,000
Aphelion Conjunction	3·657	340,000,000	547,200,000
Equatorial Diameter		4,220	6,780
Length of day Sidereal	24 hr. 37 min. 22·668 sec.		
Solar	24 hr. 39 min. 35·247 sec.		
Length of year	668·599 Mars days 686·979 Earth days		
Inclination of equator to orbital plane	25° 10		
Mass (Earth = 1)	0·108		
Volume (Earth = 1)	0·151		
Density (Earth = 1)	0·710		
Density (Water = 1)	3·910		
Surface Area (Earth = 1)	0·278		
Surface Gravity (Earth = 1)	0·380		

It is salutory to realize that even this information, in which we have complete confidence, is arrived at quite indirectly. We do not yet have observatories on Mars with transit instruments to measure Martian sidercal time, or with pendulums to determine the local constant of gravity.

The length of the Martian day could not be measured until Christiaan Huyghens had discovered the dark surface markings (the seas) in 1659. In fact we owe our extreme precision in the measurement of the period of rotation to a sketch he made showing Syrtis Major on the central meridian on November 28, 1659.

The mass and the surface gravity are deduced from the orbits of the two satellites of Mars, Phobos and Deimos, which were discovered in 1877 by Asaph Hall (see *Spaceflight*, No. 3). Newton's law of gravitation enables us to calculate the planetary mass required to hold the satellites in their orbits.

Whilst it is quite easy to measure the angular diameter of Mars, its diameter in miles can only be deduced if we know how far away it is, and every student of astronomy knows how painfully indirectly astronomers established the scale of the Solar System.

Nonetheless, all these data are fitted together in that beautiful interlocked structure which is the basis of the scientific method, and we have as much confidence in them as in the most direct measurements. Combining the mass and diameter we find that Mars has a density of only 0·71 the Earth's. Considering this density Professor Bullard has pointed out that Mars could hardly possess the sort of dense fluid core which the Earth has. At present it is thought that the Earth's magnetic field originates in a sort of dynamo effect in this core, so that if this is true Mars will have no general magnetic field. Now this is just a speculation, which is unlikely to be resolved until a magnetometer reading has been taken close to the surface of Mars, but scientists will not be surprised if a magnetic compass fails to work on Mars. A gyro compass would behave quite normally.

As we start taking a closer look at Mars we embark further into this realm of speculation.

The Orbital Motion

In this article we are principally interested in the restrictions which the relative motions of Mars and the Earth impose on observers. The current opposition was on November 16, and Mars was then 45,000,000 miles away with a diameter of 19·2 seconds of arc. Because the orbit of Mars is not quite circular some oppositions bring the planet almost twice as close as others (Fig. 1), but for people living in England size is

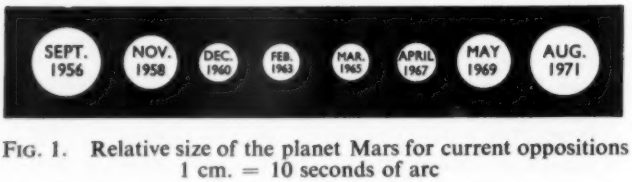


FIG. 1. Relative size of the planet Mars for current oppositions 1 cm. = 10 seconds of arc

not everything. It is unfortunately true that the nearest oppositions all come during our summer, when the ecliptic plane is low in the sky at night.

During the 1956 opposition the two most important accessories to my telescope in attempting to observe Mars were hedge clippers and pruning saw. The orbit could be traced the next morning from the telescope site by the trail of devastated hedge and bush. Observation under these conditions is, however, frustrated not only by vegetation but by the thick layer of turbulent atmosphere.

This is why the professional astronomers view perihelic oppositions from observatories like Bloemfontein in South Africa, where Mars appears high in the sky.

It must never be forgotten that at these close oppositions we always see Mars with its southern hemisphere turned towards us, whilst in the poorest oppositions it is summer in the northern hemisphere. Thus we always see the southern hemisphere when it is only half as far away as of the northern hemisphere. It is not surprising then that the northern hemisphere usually shows much less detail on any maps that we may examine.

Areography

The study of Martian topography was christened "areography" at the end of the eighteenth century by Schröter, the great lunar observer. He derived the term from *Ares*, the Greek name for Mars. Geography is derived from the Greek for "Earth", and is obviously inappropriate.

Mars has white polar caps, dusty red areas covering two-thirds of the surface, and darker areas joined by thin lines which cross the desert areas like a network of fine veins. (Fig. 2.)

Polar Caps

During the long Martian year the polar cap turned towards the sun can be observed to be shrinking steadily (Fig. 3) and at the same time we can infer that the other polar cap is being replenished, for in due course it may be observed fully grown and shrinking in its turn as 0·9 Earth years, later the opposite pole is turned towards the Sun. There has often been some confusion about the process of growth of the polar cap, for there are no published data on this phase of the cycle. There never can be, for this takes place during the long polar night when the pole is not only turned away from us but from the Sun too. Whenever we observe one of the caps being dissipated the growths of the other cap is simultaneously taking place, secretly in the dark just around the limb of the planet.

Can we be sure that the caps are solid water? The elder Herschel immediately assumed that they were, but doubts arose when water vapour could not be detected spectroscopically. Temperature measurements reassure us by providing a reason for this failure. The atmosphere and surface are too cold to provide enough water vapour for the H_2O absorption bands to be measurable by our present techniques. The evaporating polar cap shows temperatures of about $-50°$ C. as determined by tiny thermocouples placed in the radiation. Spectroscopic work by G. P. Kuiper indicates that they are indeed composed of ice.

Mars, 1958. Drawing by J. D. Bestwick, 12 in. Reflector

As the polar cap shrinks it becomes surrounded by a darker region. For some time it was contended that this was simply an effect of contrast, but careful observation has now shown that the effect is quite real. Many astronomers have seen in this darkening evidence of melting of the ice to form a region in which the ground has been darkened by moisture, or even by the formation of shallow lakes or marshes. This seems most unlikely, for both observation and calculation concur in the verdict that the ground temperature at the midsummer pole cannot rise above −40° C. The melting point of ice is 0° C. even on Mars.

It seems reasonably certain that the supposed ice simply evaporates without melting at all, a process known as sublimation which seems quite unnatural to people who live in England. Here when snow has fallen it always is removed by melting. In continental climates everyone is quite familiar with the astonishingly high rate of direct evaporation of snow, and the process is particularly familiar to mountaineers.

All this leaves the darkening round the pole unexplained. It may simply be due to the same agency which causes the darkening of the "seas" and "canals" at the same time of the year.

One interesting consequence arises from the observed evaporation of the polar cap. It cannot be a very thick deposit, for there is just not enough heat available to completely evaporate a thick deposit. Current opinion suggests something less than a one-foot thickness of ice, or is a fully developed polar cap 3,000 miles in diameter some 1,000,000,000,000 tons of ice. All (or nearly all) this water is removed from one pole and deposited at the other twice every Martian year. Although this may seem like a lot of ice, when melted it would barely fill one of the Great Lakes of America.

Deserts

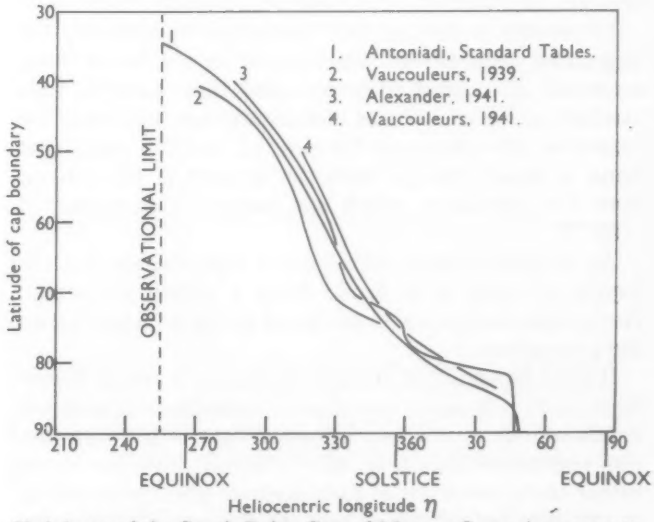
The reddish-hued areas are generally accepted as deserts for much the same negative reasons as the caps are supposed to be ice. Certainly clouds of a similar colour are often observed to pass over the darker regions, and these are taken to be dust storms. These deserts are, however, of quite a different kind to the deserts encountered on the Earth, for the temperature seldom rises above freezing point even along the equator. The existence of such a frigid desert is only possible because of the extreme aridity of Mars.

Attempts to determine the chemical constitution of the deserts must rest of course on an examination of the reflected light from them. Unfortunately light reflected from a solid surface rarely conveys any unambiguous information on the composition of the solid. There are as many different opinions on the composition of the Martian deserts as there are scientists working on the problem, which in itself is a fair indication that we don't really know what the deserts are.

Seas

The dark areas occur in a well defined band between 15 and 60° south of the equator, and rather more sparsely in a similar band north of the equator. This lack of symmetry may in part be due to the southern summer falling at perihelion, so that it is appreciably hotter than the northern one. It has already been pointed out that the northern hemisphere is never seen so well from the Earth as is the southern, so that some of these differences may only be apparent.

The dark patches were called seas by Herschel, but we now know that (like the lunar seas) they are really dry land. Thermocouple measurements show that they are in general some 15 to 20° C. hotter than the surrounding desert areas, and at midday in the tropics they rise to 20° C. It would be a mistake, however, to suppose that



Shrinkage of the South Polar Cap of Mars. Curve 1 represents Antoniadi's tables based upon analyses of several series of observations. Curves 2, 3 and 4 are based upon actual observations between 1939 and 1941. It will be seen that the departure from Antoniadi's tables is not great

this would be "comfortably warm". This temperature is the sunlit surface temperature, and the thin air a few feet above the surface probably remains frigidly cold. We should remember that eggs can traditionally be fried upon pavements exposed to the tropical sun here on Earth.

When we consider the composition of the dark areas we are once again in a very similar position to that over the "deserts". Definite proof of any hypothesis is unlikely for much the same reason, but because the dark areas show definite seasonal changes there is more evidence on which to base these hypotheses. For a long time two theories held the field—that they were vegetation of some kind dependent upon water released from the shrinking polar cap, or that they were hygroscopic mineral deposits which darkened for the same reason (Arrhenius). Recently Öpik has pointed out that the observed dust storms might be expected gradually to engulf any dark area without the sort of regenerative power associated with vegetation, whilst in point of fact during the 200 years in which we have observed Mars the dark areas have in general grown larger. This argument has been countered in the last two years by McLaughlin's suggestion that the dark areas are maintained by the distribution of volcanic ash from active volcanoes by the Martian atmospheric circulation. The ash itself is then supposed to be hygroscopic. This is an ingenious idea, but it does not explain the canals.

Canals

Nowadays there is no real doubt about the existence of the "canals", although they are not the mathematically straight lines subject to doubling or "gemination" which Lowell and Pickering drew. These are undoubtedly subjective optical effects superposed on the real structure of veinlike lines described by Richardson (*Spaceflight*, No. 3).

Personally I favour the vegetation hypothesis, the vegetation then being concentrated in the lower lying areas, as it is on Earth, provided that water is also available. On this basis the canals are evidence for extensive rift valley type formations, and the equatorial band is desert because here the dryness is too intense even for vegetation which can survive a dewpoint of $-50°$ C.

As we have already seen there is little chance that the supply of water is as liquid from a melted polar cap. A possible mechanism is discussed in the next section on the atmosphere.

It must be admitted that the vegetation is very different from ours. It does not show chlorophyll absorption bands, nor does it reflect infra-red light in the way that our vegetation does (Fig. 4). There is, however, some rather shaky evidence of carbohydrate absorption bands in the infra-red spectrum, and the Russian school under Tikhoff has pointed out that Siberian vegetation exposed to a cold climate appears to have increased absorption coefficients in the long wave region.

Martian Meteorology

It was realized by Herschel that Mars had an atmosphere, and as soon as there is an atmosphere we have weather to contend with. As was pointed out recently by Goody (*B.I.S.J.*, Vol. 16, No. 2, p. 69, June, 1957) "sufficient information is now available on the Martian atmosphere to make its study a serious and rewarding task". This article by Goody is a mine of information.

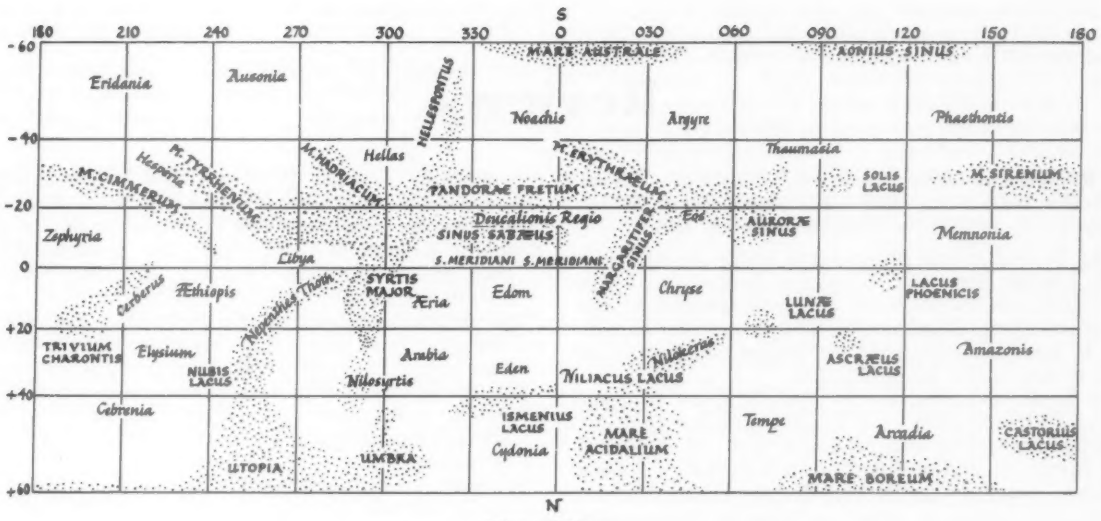
Perhaps the most important single fact concerning the atmosphere is its pressure at ground level. Once again this is only measured most indirectly by determining the light scattering power of the atmosphere, and comparing it with our own. These measurements all suggest a pressure of only 70 mm. of mercury, as compared with our 760 mm. Although the surface pressure is only one-tenth of ours the total amount of atmosphere is surprisingly large—about 3·50 lb. mass per sq. in., as compared with our 14·7. The lower pressure is of course due to the smaller gravitational field. With this reduced gravity Mars has held on to this atmosphere surprisingly well.

One of the most interesting speculations which arises concerns human survival on the surface, and aviation medicine now gives us an answer on survival at low pressures in just this range (P. A. Campbell, *J.B.I.S.*, Vol. 14, No. 1, February, 1955). Clearly a human being on Mars must be supplied with oxygen, for the oxygen content has been shown to be less than 1 per cent. Breathing pure oxygen in a well fitting mask a seated person can remain conscious and fully effective under a pressure of only 140 mm. of mercury. At a pressure of 70 mm. of mercury, however, the person becomes unconscious in about 30 seconds.

Thus if the pressure on Mars is 70 mm. of mercury a breathing mask is definitely not enough. A pressure suit of some kind will be required for survival. Moreover, even though we are not very certain of the real pressure there is little chance of being wrong by a factor of two. In fact 70 mm. is likely to be an overestimate. Nor is there any chance of improving matters by finding a really low lying area, for in order to double the pressure we would need to find a depression some 30,000 ft. deep. The best we can say is that in the Martian seas a fully adapted person might survive for several minutes in an oxygen mask.

Returning to the question of Martian meteorology we are presented with the interesting possibility that the science of meteorology may benefit enormously from a closer study of Mars. The planet provides a model which retains a seasonal radiation balance like the Earth's, with an atmosphere which can probably be treated as a perfect gas uncomplicated by precipitation problems or by land and sea areas. It may be possible to proceed from analysis of the general circulation of the Martian atmosphere towards an understanding (which is completely lacking at the moment) of our own.

The composition of the Martian atmosphere is more amenable to measurement than are the solid features,



Map of Mars

[From "Guide to the Planets": Patrick Moore, 1957. 12½ in. Reflector]

because the light reflected from the surface actually passes twice through the atmosphere, and each constituent absorbs its own characteristic wavelengths. Thus the identification of the constituents of the Martian atmosphere is simply a matter of the spectroscopic technique required to distinguish their absorptions from those taking place in the Earth's own atmosphere. Even so, only carbon dioxide has been identified with any certainty, at a concentration of 1·5 per cent. The water and the oxygen if present at all cannot exceed 0·01 and 0·15 per cent. respectively.

When we consider that white clouds are observed especially over the polar caps and in the early morning and evening skies it seems reasonable to assume that they are probably clouds of ice crystals similar to the highest cloud forms observed in our own atmosphere. As the water is deposited from these clouds to form the polar cap it is possible that snowstorms do take place on Mars, but it seems certain that there are no rainstorms. The ice would evaporate before it could melt. It seems to me that the observation of the extremely dusty nature of the air supports this view, for we know that rain is the principle cleanser of the air here on Earth. We also know that when exceptional circumstances lift quantities of dust out of the Earth's troposphere beyond the scrubbing action of the rain then it remains in suspension for a long time.

One possible explanation of the so-called "violet layer" lies in this dustiness of the atmosphere. It would produce just the obscuration of surface detail in blue light which is observed. It is not, however, easy to see how there could be a "blue clearing" for short periods with this mechanism. If the violet layer is dust then we may reflect that the Earth now has the dubious distinction of posessing a home-made radioactive violet layer.

If we accept that the polar caps are transported entirely by evaporation, then clearly the supply of water to the surface is exclusively a meteorological problem. As the moisture bearing gases (one can hardly call a dewpoint of −40° C. water laden) move out from the polar cap they will clearly not deposit any water in the warmer lower latitude regions during the day, but at night the temperature here falls far below this dewpoint. It seems likely then that the water in these regions is supplied as a thin frost which merely re-evaporates from the desert shortly after sunrise, but is trapped and used by the vegetation growing in the darker regions.

Conclusions

In spite of the application of all the resources of modern astronomical technique we see that Mars remains more the subject of speculation than of established fact. It cannot be too strongly emphasized that the familiar picture which we all carry may be very far from the truth. Only when vehicles from the Earth have carried men or machines out to Mars will this situation be substantially changed. We should perhaps be thankful that the astronomers leave the astronants plenty to discover, whilst telling us enough to whet our curiosity.

Continued from page 23]

stoutest advocates of a British space research programme. C.O.S.P.A.R., as the I.C.S.U. space research committee has been calling itself, held its meeting in private. First the Russians weren't coming, then they were; in the end they sent two senior representatives, Profs. Blagonravov and Sedov.

16 *November.* Moscow Radio yesterday broadcast a speech by Mr. Kruschev to Soviet Military Academy graduates in which he said that Russia was preparing for "flight to celestial bodies" as part of "the new era in the history of mankind—the era of mastering cosmic space".

Reviews

Satellites, Rockets and Outer Space. By Willy Ley. Signet Key Books, New York, 1958. 128 pages. Price 3s. 6d. Distributed in Britain by Frederick Muller, Ltd.

Illustrated by four colour photographs and a superb cover painting by Chesley Bonestell, *Satellites, Rockets and Outer Space* inevitably covers some of the same ground as the author's earlier astronautical works, though, needless to add, references to Sputniks and to the impending despatch of an unmanned rocket to the Moon abound.

The new book, dedicated to "all who believed in space travel before 4 October, 1957," is addressed primarily to the younger generation (there is a reference to R. H. Goddard as "young Robert"!), and the first of its five sections, "Calling All Spacemen," among other things, offers some sound advice to all those who aspire to make astronautics their career. Thereafter, discussions about rockets, missiles and artificial satellites are followed by accounts of various lunar projects. The final section deals most efficiently with the flying saucer epidemic. In brief: authoritative, informative and brightly written.

P. E. CLEATOR

What's going on in Space? By Commander David C. Holmes, U.S.N. Funk & Wagnalls. 256 pp. 3.95 dollars.

This is one of the "second generation" of space books. That is to say, it recounts the launching of artificial satellites besides dealing with astronautical history and future prospects. Including as it does Explorer III, this book is in fact as up to date as may reasonably be expected.

Even without looking at the wrapper, one does not read many pages before realizing that the author is no literary novice. With numerous magazine stories and articles and eight books published, he is well equipped for the difficult task of writing lucidly and entertainingly. Moreover, as an amateur astronomer and Navy man with experience of guided missile programmes, he has the technical background essential to a ready exposition and sober evaluation of the problems and possibilities of rockets and space flight.

The intense mortification which descended on America simultaneously with the successful ascent of Sputnik I is common knowledge. Commander Holmes, though himself plainly mortified, is nevertheless generous in his acknowledgements of the Russian achievements, which are frankly and equitably compared with U.S. projects. Indeed, perhaps the chief interest of this book for all but newcomers lies in the opportunity it provides to compare the Russian and American commentaries of post-sputnik days. With these before him, the reader should have little difficulty in forming an opinion as to which side really carries the biggest stick and speaks softest.

On the whole, the author makes a good job of selling interplanetary travel. However, on reaching page 216 I was shocked to find the statement that "certainly no one will want to live on the moon even if conditions get far worse on earth than they are to-day". Speaking not only for myself but on behalf of many astronauts of my acquaintance, I would say that this is quite untrue. Colonization of the Moon and other worlds is a specific astronautical intention. For one thing, we cannot thoroughly explore other worlds without founding permanent bases independent of fabulously expensive supplies from Earth. Secondly, colonization of other worlds furnishes opportunity for a scientific approach to the problems of social organization. In fact it offers prospect of a new Genesis.

Arriving at page 218 I was not only shocked but also scandalized—this time, however, by Dr. S. F. Singer. Here is retold his suggestions that the Moon be used as an H-bomb testing ground, that the craters thus made might be named after presidents, prime ministers, and party secretaries, and that the explosions would be useful as salutary reminders of the destructive power of the H-bomb. Although I suspect that Dr. Singer was frivolously angling for megabucks in at least one of his suggestions, I for one am very sorry that an otherwise reputable, responsible and respected scientist should make such unscientific proposals. If this is the childish use we are to make of the Moon, then I am against astronautics.

Most articles and books for the non- or semi-technical public contain questionable data, explanations or phrases. Sometimes these are the result of momentary aberration, as when (page 49) the author remarks: "In order for the rocket to leave the earth's magnetic grasp . . . it must achieve a certain escape velocity". This example shows how easy it is to slip up when writing down to popular level. The commonest instance I know is the journalistic oversimplification which resolves itself into talking of "getting beyond Earth's gravitation". On second thoughts, this statement is made so often that some writers must actually believe that to be not only possible but essential.

But let us all take heart—no one is infallible—not even the *Concise Oxford Dictionary*, which in my edition defines Astronautics as the "science of *aerial* navigation in space". Truly, even Homer sometimes nods.

Not the least attractive feature of this book, at any rate so far as I am concerned, is the light sprinkling of humour which enlivens its pages. But quite apart from that it is well worth reading. Old material is burnished and the new is floodlit. All in all, it is the best book of its kind that I have read in a long while.

H. E. Ross.

Introduction to the Moon. By Dinsmore Alter. Published by Griffith Observatory, U.S.A., 1958.

This book, written by the former Director of the Griffith Observatory, is paper-backed, and runs to 108 pages. There are 19 chapters, dealing with early lunar work, the surface features, and developments of the future; there is for instance a chapter dealing with space-stations.

Dr. Alter is well known as a selenographer, and has taken many excellent photographs with very large telescopes. Many of these are included in the present book, and form indeed the major portion of it. A typical example is the series of pictures illustrating the crater Copernicus throughout a complete lunation; the apparent changes are vividly shown. Various other points are also brought out. There is, for instance, a plate showing typical craters in cross-section, making it clear that a crater is not a deep, well-like formation —but more like a shallow saucer.

It is refreshing to find a book of this type which is so obviously in sympathy with the whole idea of astronautics. However, the main emphasis is naturally astronomical, and the text is extremely clear. Errors and misprints appear to be almost entirely lacking. The book will be useful alike to the beginner, the serious selenographer, and the would-be astronaut. It is well planned; the only real criticism is that there is no outline map naming the various formations—the only full map is a photographic representation.

This, however, in no way detracts from the value of the book. Author and publishers are to be congratulated upon

producing a work which should be in the hands of everyone interested in lunar studies. P. M.

The Present and Future of the Telescope of Moderate Size. Edited by F. Bradshaw Wood. University of Pennsylvania Press, Philadelphia, 1958. 219 pp + frontispiece. 40s.

This book is a collection of papers contributed to a symposium held in connection with the dedication ceremonies of the Flower and Cook Observatory of the University of Pennsylvania, and consists of fourteen papers, some of considerable length, each by a different author. It is as well to be clear at the onset as to the scope of this book, as the title may be rather misleading. By the term "telescopes of moderate size" is meant anything between 12 and 40 inches aperture, so that for this reason alone, the scope is rather beyond that covered by the average amateur. Secondly, most of the book is concerned with electronic methods of improving the performance of the telescope, using rather complicated apparatus, which would be difficult for the amateur to construct. For these reasons, this book, which is otherwise excellent, may tend to mislead in its title. It is written with the professional astronomer in mind, and makes no concessions to the amateur owner of the small telescope.

The first chapter deals with "Image tube developments and the small telescope," and is by W. A. Hiltner. It describes how, by using a photomultiplier, an 82-in. telescope was made to receive information 10 per cent. faster than the 200-in. Most of this chapter is concerned with the detailed description of an image converter in which the photographic plate is separated from the photocathode by a thin metallic foil so as to prevent destruction of the photocathode. This method solves the problem of the photocathode destruction caused by the chemical reaction of the cæsium in the cathode with the water in the emulsion. The choice of a metal film which gives protection without causing deterioration of the image is dealt with in detail.

Electronic photography is next dealt with in a chapter by A. Lallemand. Here we are told how the image to be observed is allowed to fall on a surface which consequently emits electrons when it receives photons. These electrons are accelerated by an electric field without losing the image, and then register on an electron-track plate. The development of this plate gives a result of much greater resolution than would be obtained using the normal method of photography.

This same problem is also considered in the next chapter, entitled "Photoelectronic Problems in Astronomy," by J. D. McGee. Here the author considers the detection of very faint optical images, and tells how the use of photoelectronic techniques produces a method about a hundred times as efficient as the ordinary recording processes. The image converter tube is described in detail, together with a certain amount of theory.

Chapter 4 describes the recent work done at Cambridge investigating image detectors, and is written by P. Fellgett. Sensitivity assessments are considered, both from the point of view of response and informational efficiency. It is pointed out that there is no need to make detectors more sensitive unless an increase in informational efficiency can also be obtained. There are some interesting figures about this. It is shown that a high grade television receiver capable of handling 10^8 bits per second would cost $33,000 per second to run if the cost per bit were the same as that for the telescope considered. Lack of efficiency in the sorting out of information may reduce the usefulness of the data by a factor of 1,000. On page 62 is an interesting graph showing the relative sensitivities of the human eye and various other image detectors. The mathematical theory of the action of photographic emulsions is considered in detail in this chapter, together with that of other types of image detectors.

The next chapter, by Hall and Hoag, deals with the recording of information using the punched-card method. Then follows a chapter dealing with the Newton-Lacy-Pierce photometer which was designed for variable star observations. A description of the construction and operation of the instrument is given.

Chapter 7 deals with the extension of photoelectric photometry into the region of the infra-red as far as 40μ. The choice of a suitable detector in terms of spectral response and noise-equivalent power is described. Graphs of the black body radiations at different temperatures corresponding to various types of star are given, together with block circuit diagrams of various detecting systems.

The next chapter is a general survey of the development of the use of photoelectric cells with small telescopes, and contains some interesting historical observations and personal anecdotes. The author, G. E. Kron, points out that this growth in the use of photographic surfaces was one of the many good things not resulting from the recent war.

The remaining chapters of the book all deal with some aspect of stellar photography. Chapter 9 is on "Photoelectric Studies of the Scintillation of Starlight," and is of particular interest as it describes the use of a small 4-in. telescope with a photomultiplier attachment, which is probably within the scope of the amateur astronomer to construct. Only certain aspects of the subject are considered here, one of which is the correlation between the scintillation and upper air velocities. Several interesting graphs illustrating this effect are given, although at the time of writing it was not possible to come to any definite conclusions as to the extent of the correlation. Some work using two 2·5-in. telescopes is also described. The author, W. M. Protheroe, concludes that "the study of scintillation using small telescopes shows promise for the study of interesting astronomical problems."

Chapter 10 is an account of "Our Knowledge of the upper Atmosphere from Studies of the Scintillation of Visible Starlight," written by G. Keller. It is stated here that the principal agency responsible for optical star scintillation is located in the troposphere and possibly the lower stratosphere. It is generally agreed that the rapid fluctuations in brightness of stars are probably caused by the passage of the light through atmospheric regions of irregularly varying refractive index. This point is discussed in this chapter, and a mathematical analysis is given.

The next chapter, by P. van de Kamp, is called "Precision Problems in Photographic Astrometry." It is concerned, in the words of the author, with "(1) Those problems in astronomy that require high individual positional accuracy; (2) those technical problems that arise in aiming for high accuracy, or in other words, the limitations in accuracy."

The paper is mainly concerned with the problems associated with long focus refractors, and contains a discussion of the importance of keeping the measuring technique as constant as possible, including the optical performance of the telescope. The question of systematic errors in observations is also considered.

The last three chapters consist in the main of a discussion of some of the future problems in stellar observation. Chapter 12, by A. N. Vyssotsky, is entitled "Some Future Problems in Astrometry," and gives particular reference to the statistical studies of the proper motions of the stars carried out by the author. The next chapter, by B. S. Whitney, on "Variable Star Programmes, Present and Future," is a general survey of the work yet to be done in this field. The final chapter, entitled "The Present and Future use of Stellar Spectroscopy with Moderate-Size Telescopes," by D. B. McLaughlin, discusses the possibilities of future work in the field of slit-spectroscopy. The design of spectrometers suitable for use with moderate sized telescopes is dealt with in some detail, and the chapter ends with a summary of the type of work that can be carried out with this equipment.

Although this book is a collection of separate papers, these have been selected in such a way that the completed volume presents a satisfactory unity. The high standard is maintained in every chapter, and the topics covered will not be

found in any other single volume. It must be emphasised, however, that this book is intended more for the professional astronomer or astronomical student rather than for the amateur, because it assumes a considerable knowledge of electronics and photo-electricity and makes few concessions to the layman in these fields. With this proviso, it can be said that the book contains much interesting information, and is well produced and written. There are numerous references at the ends of most chapters, but an index would have increased the usefulness of the book. N. H. L.

Countdown for Tomorrow. By Martin Caidin. 8 × 5 in. Pp. 277, with 43 illustrations. New York: E. P. Dutton & Co., Inc. 1958. $4.95.

The prospective reader of this book should not be misled by its title. It is not a technical book in the sense that it deals with the science and engineering of rockets, satellites and space travel. Nor does it belong to the now large family of speculative books which predict the near and distant future and the wonders that we or our children will see.

In fact, it is an indictment of the American Government and armed forces, accusing them of mishandling missile and satellite development in the U.S.A. since the end of the Second World War. This main theme of accusation is interspersed with popular and semi-technical descriptions of past and current rocket and satellite projects in the States, culminating in Vanguard.

It is important to realise that the book went to press at the end of 1957 between the launchings of Sputniks I and II and the first successful American satellite. Thus, to Mr. Caidin, the Russian Sputniks are vital and significant sign-posts indicating that the Soviet Union is in fact ahead of America in the race to gain supremacy in space. Mr. Caidin shows no hesitancy in assuming that Russia's main aim in life is the suppression of the U.S.A. His basic assumption is that rockets are for war, and in particular for war between Soviet Communism and American Democracy. He suggests that the balance of power in the last few years has been in favour of America, but only because of the all-powerful U.S. Strategic Air Force. Due to financial strangulation, lack of overall integration and inter-service jealousies, America's feeble and ineffective developments in the missile and satellite field have now let the scales tip decisively towards Soviet supremacy.

From his competent descriptions of the many and varied rocket projects in U.S.A. since the end of the war, it is easy to see that Mr. Caidin has an engineering background. This may be one of the factors behind his contention that the scientist and engineers must not be blamed for the short-comings of America's missile armoury, but rather the administrators and politicians. Much of the critical scrutiny which Mr. Caidin brings to bear appears sound and if his accusations are direct and pointed they nevertheless ring true. One may wonder, however, if such recent history can be put into perspective from such a short distance. Already, some of America's "prestige" has been regained by the successful Vanguard and Explorer satellites and by the semi-successful lunar probes.

While Mr. Caidin moves among the numerous projects and organizations with eminent agility, the reader less familiar with the complex of government agencies, military establishments and industrial organizations may have a hard time trying to keep up with him. However, the writing throughout is vivid and realistic, and one would swear that Mr Caidin must have been present at some of the events he describes. For example, when portraying the launching of Sputnik I, he writes: "One man slaps his comrade on the back in a gesture of happy affection; his companion grins, stainless-steel teeth reflecting in the light. . .".

When Mr. Caidin dodges nimbly back to the early days of rocketry, the descriptions of the lives and achievements of the pioneers (such as Tsiolkovskii, Goddard, Oberth and von Braun) make fascinating reading. It is a sad reflection on human nature and the way that men handle their affairs, that such high aspirations as motivated these pioneers should come to be governed by the grim and sinister forces that are the subject of this book.

D. J. CASHMORE

Rockets and Missiles. By Maurice Allward and J. W. R. Taylor. Ian Allen, 1958. 36 pp., illus. 2s. 6d.

The first edition of this paper-back appeared in March, 1956, and was entitled *ABC of Rockets and Space-Travel.* In this new and enlarged version the authors state, in an introduction, that "the number of known missiles has increased to nearly 100, and new developments appear at a rate which makes it difficult to keep track of them all. There are, in fact, so many that we have decided, in spite of all the exciting things happening in the world of space travel, to devote this ABC to missiles and rockets only".

The present reviewer considers such a decision unfortunate, and it is disappointing to find vehicles such as the satellite launchers relegated to the last two pages. Moreover, missiles become out of date as quickly as space probes. With this reservation, Allward and Taylor have done an excellent job. So far as security regulations permit, all the details of rockets and missiles are here, and each type is illustrated with a photograph of high quality. It is clear that much care has gone into the compilation and arrangement of the booklet, and the general impression is of a reliable and useful reference list.

In a year or two there will no doubt be a call for a third edition, and this time it is to be hoped that space probes will take their proper place in a publication of this sort. Meanwhile, *Rockets and Missiles* must be ajudged excellent, and the publishers have done well to make it available at a price of only half a crown. K. E. S.

Discovering the Heavens. By I. O. Evans. Hutchinson, 1958. 208 pp., illus. 12s. 6d.

The sub-title of this book is "A Junior History of Astronomy", and the author is clearly writing for those of the under-18 group. Any reader aged ten or more will be able to follow the whole book without the slightest difficulty. This is not to say that Mr. Evans "writes down" to his readers; in fact his style is extremely good, and herein lies the strength of the book. One has the impression of a layman writing for other laymen, but doing it very well.

The author begins in the very distant past, with "Compass and Calendar", "The Star-Pattern", and "Changes in the Sky". These early chapters are particularly pleasant, and convey a very faithful idea of astronomy as it used to be in ancient times. In Chapter 4 we read how "Astronomy Becomes a Science"; in later chapters great men such as Tycho Brahe, Kepler and Galileo are described, and the last hundred pages amount to what is really an outline of modern astronomical thought, though still treated with an historical bias.

When describing the whole story of astronomy in only two hundred pages, a certain over-simplification is inevitable. In the main, however, the author has avoided such a trap, and the result is a book which will make an excellent Christmas present for a scientifically-minded youngster. The print is clear, and the illustrations, by Patricia A. Cullen, very satisfactory. It is moreover a relief to find a children's book with a really comprehensive index. J. H.